UNIVERSIDADE TÉCNICA DE LISBOA

FACULDADE DE ARQUITECTURA

SUSTAINABLE REGENERATION OF INDUSTRIAL BUILDINGS TO ASSURE MODERN DAY NECESSITIES

INNOVATION AND DESIGN AS DRIVERS OF SUSTAINABILITY AND DEVELOPMENT IN ODIVELAS

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(Bachelor degree)

DISSERTATION TO OBTAIN THE MASTER'S DEGREE IN
ARCHITECTURE

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ABSTRACT (234 words)

The refurbishment of industrial buildings can serve as a proactive promoter of the area and as a key factor for a sustainable city in social, environmental and economic components. This dissertation analyses the three components, focusing on the social through the program and the refurbishment design of an industrial building complex, from the early twentieth century, located in Odivelas, as a case study.

The methodology is based on the analysis of the literature in the fields of refurbishment, sustainability and the intervention site, and of four main reference cases. It is supported by six workshops in the field of sustainability, by interviews to key personalities from the studied thematic and by the final project itself, which consists in a centre of innovation by design that comprises coworking, exposition and conference spaces.

The proposed intervention should promote and inspire new ways of use, so the buildings become flexible and can consequently be adaptable to changes in order to survive time. Therefore, the building does not take into account only its future impact in the environment and society. Instead it focuses on its entire life cycle.

This project analysis discusses if refurbished buildings can serve as better incubators for artists and entrepreneurs, due to the low costs compared to new buildings, and the existence of a wide variety of areas favourable to innovation and, in a broader scale, favourable to the sustainable development of it's city.

KEY WORDS _ Regeneration; Refurbishment; Industrial buildings; Creative industries; Sustainability.

Título _ Regeneração sustentável de edifícios industriais para assegurar as necessidades quotidianas – Inovação e design como impulsionadores da sustentabilidade e do desenvolvimento em Odivelas

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RESUMO (229 palavras)

A reabilitação de edifícios industriais pode servir como fonte dinamizadora da área e como factor chave para uma cidade sustentável nas componentes social, ambiental e económica. Esta dissertação analisa as três componentes, focando-se na social através do programa e da reabilitação de um complexo industrial do inicio do século XX, localizado em Odivelas, que servirá de caso de estudo.

A metodologia passa pela análise de literatura de referência no campo da reabilitação, sustentabilidade e do lugar a intervir, de quatro casos de estudo principais, tem como suporte seis workshops na área da sustentabilidade e entrevistas a personalidades chave nos âmbitos em estudo. Por fim, passa pela realização do projecto final de mestrado que consiste num centro de inovação pelo design, que engloba espaço de coworking (colaborações criativas), espaços expositivos e de conferências.

A intervenção proposta deve promover e inspirar novas formas de uso, de modo a tornar o edifício mais flexível e adaptável para sobreviver à passagem do tempo. Assim, o edifício tem em consideração o seu impacto no ambiente e na sociedade durante todo o seu ciclo de vida.

A análise deste projecto questiona se edifícios reabilitados podem servir como melhores incubadoras para artistas e empreendedores devido aos seus baixos custos comparativamente a edifícios de escritórios recentes, bem como oferecerem uma maior variedade de áreas favoráveis à inovação e, numa escala mais alargada, ao desenvolvimento sustentável da cidade.

PALAVRAS CHAVE _ Regeneração; Reabilitação; Edifícios industriais; Industrias criativas; Sustentabilidade.

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Sustainability is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Our Common Future: Report of the World Commission on Environment and Development

United Nations (1987)

1_ INTRODUCTION

The purpose of this dissertation is to address issues related to refurbishment of industrial buildings as a dynamic source of the area where they are implanted, fundamental for making a city sustainable in its environmental, social and economic components.

1.1_ FRAMEWORK

Taking as current framework the environmental, but mainly economical, crisis, it extends to industrial activities and to the real estate market, making it unstable and affecting the growth and development of cities, highlighting the inadequacy of uses in urban areas and creating obsolete industrial areas.

What is apparently a problem can become a major opportunity as crisis in the construction market makes the entire sector shift to the renting and rehabilitation, reconversion, restoration and adaptation market, leading to other uses with more economical solutions.

For the last 25 years of the 20th century, in Portugal[1] [2], renting values were frozen and effective legislation did not allow financial autonomy for the owners to carry out maintenance works on their buildings, which generated an increasing and gradual degradation thereof.[3]

At the same time, when Portugal joined the EEC, in 1986, it dictated the end of protectionism regarding national industry and the annulment of customs controls; the Portuguese industries, supported by low salaries and obsolete machinery and facilities, stopped being competitive regarding other equivalent plants in other European countries. This situation caused, in most of the cases, the closing of plants and created consequently large urban voids due to deactivation of such industrial complexes. On the other hand, the new noise and pollution requirements, among others, forced the still-existing plants to move from urban areas to industrial areas created specifically for that purpose.

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[1] Decreto-lei nº 217/74, de 27 de Maio, - and - Decreto-lei nº 445/74, de 12 de Setembro, [online] http://pl.proprietarios.pt
[2] **ALVES, Artur Soares** (2012) Um Século de Congelamento, 16 de Agosto [online] http://pl.proprietarios.pt
[3] **Portal da Habitação**, Uma Breve História do arrendamento urbano: Preâmbulo do Decreto-lei nº321 B/90, de 15 de Outubro, [online] www.portaldahabitacao.pt.

Such degradation of buildings, associated with the high value of the land plots, and consequently of the urban centres real estate, the displacement to the cities periphery and the strong investment by the recent governments in the construction of good accesses, has promoted the displacement of the population, thus emptying the urban centres.

As such, there is an opportunity for directing the construction market towards abandoned industrial quarters or buildings. Which due to their key-spot location promote demand on their own, as verified by the reference cases studied.

On the other hand, the current availability of information highways, with the creation of high-speed and wide band networks, namely with the implementation of optical fibber, allowed developing creative companies based on knowledge systems as start-ups for innovative services. Likewise, such companies benefit from a possible proximity and informality in the relation between employees from different companies and areas, who, not being isolated in traditional corporate buildings, are more open and promote service exchange, leveraging innovation.

The necessary conditions are therefore created for a new economic logic.

1.2_ GOALS

The research aims at analysing the three components of the sustainable development triangle, focusing on the social component so as to promote and inspire new forms of use through the building design program, making it more flexible and, subsequently, more capable of surviving time.

It also intends to confirm that restored industrial buildings can be used as incubators for artists and entrepreneurs as they do not involve the costs and environmental impacts of new buildings. This promotes a mix of areas beneficial for innovation and, in a wider scale, beneficial to the sustainable development of the city where the buildings are implanted.

The goals of this thesis are therefore to:

1. Assess the environmental, social and economical components, their relations and where they meet, influence and transform architecture.
2. Systemize a set of action lines allowing an intervention according to such principles;

3. Assess the possibilities of rehabilitation and reconversion of obsolete industrial areas through new functions, thus extending the lifecycle of the buildings;
4. Study projects framed by this scope, i.e. related to the inclusion of new functions associated with creative industries and culture in abandoned buildings, both internationally and in the Portuguese context;
5. Contribute to urban regeneration as a fundamental element for a sustainable development of the city.

1.3_ METHODOLOGY

The methodology used for developing the research started, first of all, with the state of the art revision in the refurbishment and sustainability fields and that related with the place to be subjected to intervention, Odivelas. The research is based on the reference literature, six workshops on the subject of sustainability area and in informal interviews to key-elements within the scope of the study.

Secondly, in order to support the theories studied, four main case studies were evaluated, two in the international context and two in the national context.

Thirdly, the final masters Project was performed, a design innovation centre with creative collaborations, exhibition areas and conference halls in Odivelas. Part of Lisbon's metropolitan area, the city was proposed in the class of studio design for an urban intervention. This approach aimed at creating a dynamic pole integrating the principles of the sustainable development triangle. Given the degradation and current demolition of part of the industrial complex, as well as the illegal occupation it was subjected to, the survey of the constructed area was based on documents of part of the industrial complex provided by the Odivelas City Hall, as well as a site visit accompanied by a City Hall representative and local police, during which on site and photographic surveys were carried out. This project includes the relevant assessment and discussion of its contribution to the urban regeneration of the area being completed with the elaboration of the thesis.

1.4_ ORGANIZATIONAL STRUCTURE

This dissertation is organized into a three-part structure, pursuant to the work methodology. The first part, i.e., the theoretical bases, is presented in chapters 3 to 5:

Chapter 3 refers to the social component of sustainability and what it comprises. The thematic approached the importance of social equity translated in the building's program, through fab labs and cowork offices, for example. As well as the principles of universal or transgenerational design.

Chapter 4 refers to the economic component and focus on the impact of creative cities as promoters of development, and the impact of refurbishment in the local economy.

Chapter 5 refers to the environmental component, focusing on the building's life cycle; the materials used in construction, and the technology and strategies through active and passive systems.

The second part is presented in chapter 6, where, through reference cases, examples deemed determinant for the proposal and providing practical reasoning are assessed.

The third part, chapter 7 presents the proposal, its concept and proposed strategies assessed according to the acquired knowledge.

2_ STATE OF THE ART

According to the proposed subject, bibliography will focus on three subjects, i.e., refurbishment, particularly of industrial units and their contribution to urban regeneration; sustainability, focusing mainly on the social component of the sustainable development triangle; and the place to be subjected to the intervention, Odivelas.

Refurbishment and Rehabilitation

The Secretary of the Interior defines Rehabilitation as *"the process of returning a property to a state of utility, through repair or alteration, which makes possible an efficient contemporary use while preserving those portions and features of the property which are significant to its historic, architectural, and cultural values."*[4]

Rehabilitation, according to Vitor Cóias[5], is based on the notions of usability or function and, when applied to the building, two different strategies are used. One for buildings with historic value, which the author associates with the concept of "rehabilitation" previously defined. In case of a common building, Cóias associates the strategy to the British concept of "refurbishment", *"extensive repair, renovation and modification of a building in order to make it with economical or functional criteria equivalent to those required for a new building with the same purpose. It can include the performance of installations and service systems, natural lighting, equipment and finishings, using only the shell of the old building."*[6]

João Appleton associates Rehabilitation with sustainability and defines it as *"preserving a major part of the constructed elements, thus reducing the quantity of demolitions needed and corresponding reconstructions. It means using smaller quantities of energy in the production and application of construction materials, reducing CO2 emissions and limiting the quantities of demolition products to be removed and destroyed. It means, as much as possible, the use of traditional, natural materials (wood, stone, sand and lime) contrary to the use of artificial industrial materials such as cement, steel, aluminium, PVC and other polymer materials, etc.; it also means the possibility of easily reusing the demolition product, integrating them in the rehabilitated*

[4] U.S. Department of the Interior, National Park Service (1990) Standards for Rehabilitation. [online] http://www.nps.gov/tps/standards/rehabilitation/rehab/stand.htm
[5] **CÓIAS, Vitor** (2007) Reabilitação: a melhor via para a construção sustentável, Lisboa [online]. Disponível em: http://www.bancaeambiente.org/pdf/wokshop1/Reab_Sustent1.pdf
[6] **MAINSFIELD, J. R.** (2001) Refurbishment: some difficulties with a full definition. 7th int. Conf. Insp. Appr. Repairs & Maintenance, Nottingham.

work or another of similar characteristics."[7]

The concept which generated the subject for this thesis was based on the book by Edward Hollis, *The Secret Lives of Buildings*[8], which described buildings that, either due to their size or heavy structure, survived their time and function, being adapted and gaining a different "life" and functions.

"Goethe described architecture as frozen music, but I would argue that's it's not frozen at all. Architecture, interiors, landscapes evolve, over time, and trace patterns as subtle as a sonata or a symphony - only so slowly that we hardly see it happen." Edward Hollis[9]*.*

By surviving their function, the Technologies used for building them and the formal logic and aesthetics of when they were built, buildings must adapt to new needs, if necessary through additions, subtractions or rehabilitations. And when such is not possible, the building cannot survive the passage of time.

"When a place is lifeless or unreal, there is almost always a mastermind behind it. It is so filled with the will of its maker that there is no room for its own nature." Christopher Alexander[10]*.*

In *The Modern Cult of Monuments*[11]*,* (1903) Alois Riegl defines five values by which buildings and art should be preserved: the historical value; the artistic value, more subjective and which, due to changes in aesthetics, more difficult to determine; age value, such as ruins; use value, i.e. buildings that continue to be used, either because they kept their function or because they were able to adapt to new functions; and finally novelty or innovation value, i.e. pioneering buildings which continue to be relevant even after becoming standard. In 2009, Justin Davidson in his *St. Anywhere*[12] article tries to add eccentricity as value to Riegl's list considering that these buildings, by surviving, gain a personality by opposition to the remaining built blocks of the cities. An example we can find in Lisbon of such a type of building is the "Casa dos Bicos" (Fig. 2-1 and Fig. 2-2 in the next page) which, despite corresponding to other values in the list, still has this

[7] **APPLETON, João** (2010) VI ENEEC – Encontro Nacional de estudantes de Engenharia Civil, Évora, Abril.
[5] **HOLLIS, Edward** (2009) The Secret Lives of Buildings: From the Ruins of the Parthenon to the Vegas Strip in Thirteen Stories, Portobello Books

[9] **HOLLIS, Edward,** *Writing and Thinking*, *História* [online]. [citado 2012-12-09] available at: http://www.edwardhollis.com/

[10] **ALEXANDER, Christopher,** (1979) The Timeless Way of Building, Oxford University Press. (pág. 36) Disponível em: http://books.google.pt/

[11] **RIEGL, Alois,** (1903) The Modern Cult of Monuments: Its Character and its Origin, Oppositions 25 (Fall 1982): 21-51

[12] **DAVIDSON, Justin,** (2009) St. Anywhere, New York, March 23. – in – **LANGE, Alexandra** (2012) Writing About Architecture: Mastering the Language of Buildings and Cities, Princeton Architectural Press, New York.

Fig. 2.1. Casa dos Bicos

Fig. 2.2. Detail Casa dos Bicos

characteristics that makes it different from all the other buildings of the same time and function in Lisbon.

Huxtable, in 1965, in his essay *Lively Original Versus Dead Copy*[13], states that historical value makes the building into a senseless museum piece and that the building should be an integrant part of an ever growing city, that is, it is evaluated by its use and functionality. Otherwise, one is limited to untouchable, obsolete historical quarters.

Buildings with different ages make the cities more dynamic. According to Jane Jacobs in *The Death and Life of Great American Cities*[14], cities need old buildings mixed with more modern buildings in the quarters. Not old buildings, considered monuments, but rather common, with low economic value buildings. According to the author, if a city area includes only modern buildings, the type of activities and companies able to support the high costs of new areas are very limited. As such, they gain from the proximity with other economic areas, which promote diversity. According to Alexandra Lange, in *Writing about Architecture*[15], it is the diversity of use, of users and of space that makes a city well succeeded as diversity creates movement. *"New real estate is expensive real estate; old buildings are better incubators for artists and entrepreneurs." Alexandra Lange*[8].

"As for really new ideas of any kind – no matter how ultimately profitable or otherwise successful some of them might prove to be – there is no leeway for such chancy trial, error and experimentation in the high-overhead economy of new construction. Old ideas can sometimes use new buildings. New ideas must use old buildings." Jane Jacobs[7].

In what concerns the construction and recuperation component in building rehabilitation, the following was used as theoretical background regarding construction and recuperation of materials: the work *Refurbishment Manual*[16] by Georg Giebeler, which analyses in detail the constructive anomalies and pathologies through case studies; as well as the *Guia Técnico de Reabilitação Habitacional*[17] edited by LNEC and coordinated by José Paiva, Ana Pinho and José Aguiar, which concerns urban rehabilitation in its different components based on the Portuguese context; in addition,

[13] **HUXTABLE, Ada Louise,** (1970) Lively Original Versus Dead Copy, In (1992) Will They Ever Finish Bruckner Boulevard? University of California Press, Berkeley

[14] **JACOBS, Jane,** (1961) The Death and Life of Great American Cities, Random House. – in – **LANGE, Alexandra** (2012) Writing About Architecture: Mastering the Language of Buildings and Cities, Princeton Architectural Press, New York.

[15] **LANGE, Alexandra** (2012) Writing About Architecture: Mastering the Language of Buildings and Cities, Princeton Architectural Press, New York.

[16] **GIEBELER, Georg** (2009) Refurbishment Manual, Birkhäuser GmbH.

[17] **PAIVA, J.; AGUIAR, J.; PINHO, A.** (2006) Guia Técnico de Reabilitação Habitacional, LNEC-INH.

the work *Conservation and Urban Sustainable Development: A Theoretical Framework*[18] by Zancheti, was also used due to its more encompassing scope and its defence of preservation and recuperation as part of sustainability.

Sustainability

Sustainability was a concept originally used in the 17th century, in Europe, regarding forest management. So as to ensure exploration of resources while maintaining quality, it was necessary that the cutting down of trees was equivalent to the growth of new trees to ensure continuity of exploration.

The subject of sustainability, its associated concepts and its application has been discussed in conferences and workshops originating several documents. The most relevant are "Silent Spring" by the biologist Rachel Carson, in 1960, on the effects of pesticides (DDT) and which originated the environmental movements, such as Greenpeace; the Rome Club Report, in 1968; the Stockholm Declaration, in 1972, where strategies on pollution were created integrated into the UE; the Bruntland Report, or "our common future", in 1987, the same year the Base law for the environment was approved; and finally the Rio Declaration, in 1992, which originated the XXI Agenda for the sustainable growth and which presents common opportunities for developed and developing countries thoughts its "Brown" and Green" versions.

In 1987, the United Nations Commission, in its *Our Common Future* report, defines sustainability as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*[19]

In the conference on sustainable construction in 1994, in Tampa, USA, Charles Kibert describes this concept as *"creating a healthy built environment using resource-efficient, ecologically-based principles."*[20] and associates it to the following 7 principles listed by CIB[21]: reducing energy and resources consumption; reusing resources; recycling and using renewable resources; protecting and preserving biodiversity of the environment;

[18] **ZANCHETI, S. M.** (1999) Conservation and Urban Sustainable Development: A Theoretical Framework, Ed. Universitária UFPE.

[19] **United Nations** (1987) Our Common Future: Report of the World Commission on Environment and Development. [online]. http://conspect.nl/pdf/Our_Common_Future-Brundtland_Report_1987.pdf

[20] **KIBERT,** Charles (1994) Proceedings of First International Conference of CIB TG 16 on Sustainable Construction, Tampa, Florida, 6-9 November

[21] International Council for Building, since 1998 the International Council for Research and Innovation in Building and Construction. http://www.cibworld.nl/)

creating a healthy, non-toxic environment; applying the life-cycle costs and aiming for quality in the constructed environment.

Sustainability, along with rehabilitation of buildings, aims thus for the integration of such values in rehabilitation, such as energy consumption and preservation of biodiversity and healthy environment. As industrial buildings are included in large empty and uncharacterized urban areas, their refurbishment becomes mandatory. Considering the dimensions and space characteristics, these buildings are quite flexible. The integration of these principles, of constructive processes, new technologies and the integration of new functions is made easier and more susceptible of being well succeeded. At the same time they provide value to an entire area, which in turn, can promote development and give life to an obsolete, degraded and uncharacterized urban void in the city. These industrial buildings and complexes bear witness and are a physical support to an aesthetic movement of industrial architecture. Similarly to the previous century, these complexes can once again be the source of life for the quarters where they are implanted and which, in most cases, were built around them.

The instruments for complying with these construction sustainability principles can be: of a legal nature, such as laws and directives which have a mandatory component; of voluntary market schemes, assuring performance and image promotion, through brands and certifications, such as LEED, BREEAM or LiderA (in Portugal); as well as by market demand.

The key drivers for legislation change are energy directives. According to Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings [22], these account for 40% of total energy consumption in the European Union. Being real estate construction the industry sector that most uses materials and energy, producing more waste and contributing less for recycling, and being a growing market, in order for the European Union to comply with the commitment made (among other things, the reduction of green-house gases emission), the reduction of energy consumption, the implementation of passive strategies and the use of renewable energies become of utmost importance. The Directive requires the member-states to ensure that, up to December 31, 2020, that all new buildings have almost zero needs in terms of energy, whereas public buildings must

[22] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, Offical EU Journal.[online]. [quote 2012-06-07]

comply with the Directive until 2018. As the European Union imports 50% of the energy consumed and considering that 40% of such energy is associated with construction, this legislation aims at creating economic feasibility in terms of environment.

In the Portuguese context, the impact of this Directive recast will be even higher as currently, although Portugal has one of the four major renewable sources energy producing companies, the percentage of consumed energy imported by the country amounts to approximately 80%, being the most consuming sectors those of industry, transports and buildings.

The supporting bibliography, namely for these subjects, is: the *Energy Manual*[23], as this work presents a project and construction vision through sustainable and energy-effective building materials and techniques, depicting strategies with construction details through case studies; the work *Heating, Cooling, Lighting* by Lechner[24], which along with *Green Vitruvius*[25] and *In Detail: Solar architecture* by Christian Schittich[26] present strategies that, through building design, allow responding to their main needs, as well as supporting the option for mechanical support systems, when necessary.

Although important for sustainable development, pursuant to the *Our Common Future Report*, or *Brundtland Report,* from the United Nations (World Commission on Environment and Development – WCED) these active and passive strategies are only part of the three principles supporting sustainable development. The social component, related to social equity and equal opportunities in a safe and healthy environment, is usually the less discussed although it is through the building's design and program, or urban planning, that this component can be complied with.

Creative industries as regeneration component

According to these principles, and based on the assumption that when sciences cross, either among themselves or with art, or when one contacts with different skills and knowledge, it is when innovation easily appears. Similarly to the European illuminist movement, through the "Coffee House Culture" in the 18th Century England,

[23] **HEGGER, M., FUCHS, M., STARK, T., ZEUMER, M.** (2008) Energy Manual: Sustainable Architecture (Construction Manual), Birkhäuser Architecture.

[24] **LECHNER, Norbert** (2008) Heating, Cooling, Lighting: Sustainable Design Methods for Architects, Wiley.

[25] **AAVV** (2001) A Green Vitruvius: Princípios e Práticas de Projecto para uma Arquitectura Sustentável. The European Commission, Architects Council of Europe, Energy Research Group, Softech, Soummen Arkkitehtiliitto, Ordem dos Arquitectos.

[26] **SCHITTICH, Christian** (2003) In Detail: Solar architecture, Birkhäuser Architecture.

or the Gentlemen's Societies, interdisciplinary spaces appear. This allows contact between different work and study areas, not separating science from art and thus obtaining better results in all fields. As such, the program, which consists of a design innovation centre, encompasses a co-working (creative collaborations) space so as to promote such transdisciplinarity.

In *The Miracle of Bilbao*[27], a NY Times article by Herbert Muschamp, the Frank Gehry Museum is presented as an art incubator rather than a simple exhibition space, comparing it to the pioneers of "cultural revolutions" who used to set-up artists in old abandoned plants and which renovation would bring people and investors. Places would then start to be populated by shops and condominiums and land prices would increase, preventing the artists from maintaining their spaces. This happened probably more overtly in some areas of Paris. The author explains that due to its dynamic effect, the building generates development in the surrounding areas. Likewise, João Teixeira Lopes, in his text *Em busca de um lugar no mapa*[28], states that culture, mainly nowadays, is a strong promoter of development in small cities, like Odivelas:

"For some small cities, structuring an active cultural area can be a decisive element in a development strategy (…) Nowadays, it is possible to "bypass" the hierarchy of urban systems and establish strategic partnerships with peripheral agents and institutions from other countries, creating travelling cultural productions networks (shows, exhibitions…), promoting the Exchange of creators and technicians and organizing, at exceptional moments, large cultural festivals which, not seldom, gain regional or even national projection."

Alfonso Vegara, founder and president of the Metropoli foundation, enforces this by stating that *Intelligent Territories*[29] at a regional scale can better face the globalization challenges. Through a constellation of independent neighbouring cities with a strong identity, the cities complement each other creating more possibilities of success. These cities, in a smaller scale, can get their strong identity and independence through innovation services, which foment and increase the social cohesion and economic, cultural and environmental sustainability. Even though the word innovation may be

[27] **MUSCHAMP, Herbert,** (2009) The Miracle of Bilbao, (originally from *Hearts of the City: The Selected Writings of Herbert Muschamp*.) – in – **LANGE, Alexandra** (2012) Writing About Architecture: Mastering the Language of Buildings and Cities, Princeton Architectural Press, New York.

[28] **LOPES, João Teixeira**. Em busca de um lugar no mapa: reflexões sobre políticas culturais em cidades de pequena dimensão. *Sociologia* [online]. 2000, n.34 [citado 2012-06-07], pp. 81-91 . Disponível em: <http://www.scielo.gpeari.mctes.pt/scielo.php?script=sci_arttext&pid=S0873-65292000000300004&lng=pt&nrm=iso>.

[29] "Intelligent Territories", Conference Human Habitat 2013: Alfonso Vegara, Lisbon, 6 of May 2012.



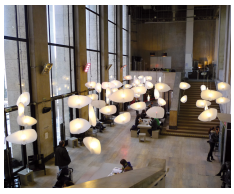


Fig. 2.3
Fig. 2.4
Fig. 2.5
Fig. 2.6

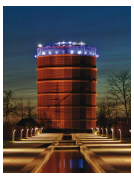



Fig. 2.7
Fig. 2.8
Fig. 2.9
Fig. 2.10

INTERNATIONAL	TATE GALERY OF MODERN ART | Herzog & de Meuron | London, UK (Fig. 2.3)
	MASS MoCA | (Massachusetts Center of Contemporary Art) | Massachusetts, USA (Fig. 2.4)
	PALAIS TOKYO | Lacaton & Vassal | Paris, France (Fig. 2.5)
	ERIDANIA PAGANINI AUDITORIUM | Renzo Piano | Parma, Italy (Fig. 2.6)
	OBERHAUSERN GASOMETER | Babcock AG | Ruhr, Germany (Fig. 2.7)
	CONTEMPORARY TEMPORARY MUSEUM | Frank Ghery | Los Angeles, USA (Fig. 2.8)
	C-MINE | 51N4E | Genk, Belgium (Fig. 2.9)
	HÜTTENWERK MEIDERICH | Landschaftspark, Duisburg, Germany (Fig. 2.10)

Table 2.1

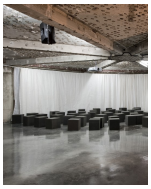
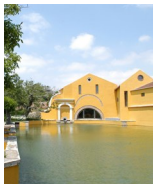

Fig. 2.11
Fig. 2.12
Fig. 2.13
Fig. 2.14




Fig. 2.15
Fig. 2.16
Fig. 2.17
Fig. 2.18

NATIONAL	MUDE | rcjv | Lisbon (Fig. 2.11)
	FÁBRICA DA PÓLVORA | Barcarena (Fig. 2.12)
	ELECTRICITY MUSEUM | Lisbon (Fig. 2.13)
	ORIENT MUSEUM | Lisbon (Fig. 2.14)
	CORDOARIA NACIONAL | Lisbon (Fig. 2.15)
	FÁBRICA DO BRAÇO DE PRATA | Lisbon (Fig. 2.16)
	LX FACTORY | Lisbon (Fig. 2.17)
	FÁBRICA DO INGLÊS | Sines (Fig. 2.18)

Table 2.2

considered a fashionable word, according to Henrique Cayatte,[30] the new solutions that can be proposed by design may not be. The design has a transdisciplinarity and is transversal through its change in scale, distance, materials and work for the individual or collective. Therefore some areas as the universal design, public space and social equity benefit from new design solutions.

As such, the social component joins the economic component debated in the above-referred reports. This program explored for the case study is analysed and based on reference cases, which are examples of rehabilitations and refurbishments, some more invasive than others; and which turned abandoned buildings into dynamic poles of their cities.

Reference Cases

So as to analyse the program concept of re-using abandoned buildings, reference cases are approached in the refurbishment chapter, including buildings where the intervention occurred due to a group of people who decided to take action. As referred above in The Times by Herbert Muschamp, these buildings maintain their degraded look and all implemented strategies have a temporary nature. They follow, apparently, the "squatting movement", very present mainly in Central Europe. However, due to their growing success, they started later on to be promoted by entrepreneurs or food chains. An example of this is the Tacheles building, in Berlin, deemed as an example from the beginning of modern architecture but showing some characteristics of classic and gothic architecture. This building combines handicraft selling galleries, a cafe, a disco and formerly, a movie theatre. In Portugal, there is the Crew Hassan Bar, in Lisbon, an abandoned building, kept only with minimum conditions, and now owned by one of the major bar and disco chains in the city.

The reference cases supporting the investigation and the final master's Project are buildings with either historic or social relevance, as well as old abandoned industrial buildings. These buildings are often object of rehabilitation, particularly as cultural spaces and helped promoting a disqualified city area. From the cases presented in the tables 2.1 and 2.2, exemplifying these principles, the following were selected:

In the international context, the first reference case is C-Mine in Genk from the architects 51N4E. It was chosen as a reconversion that combines the restoration of the old coal factory as exposition and circulation core of the building, and an extension that provides two theatre venues intended to work as cultural machines. These new volumes

[30] "Design for Innovation", Conference Human Habitat 2013: Henrique Cayatte, Lisbon, 4 of February 2013.

enhance the contrast with the original industrial building, both in light and materials, as well as in space shapes and organization.

The second case is Palais Tokyo from the architects Lacaton & Vassal in Paris. This project was chosen due to it's small intervention, according to the architects at the installation scale due to the budget, as well as due to the intention of the architects to create a closer relation with the exterior associated to the places of passage and meeting points, which is in continuous transformation and renovation according to people's movements.

The third and fourth reference cases are Portuguese examples, in order to assess the concept when applied in the national context. The third case is the Gunpowder Plant, in Barcarena. This building, as well as Lx Factory, the forth case, is a former industrial complex. Both buildings are used 24/7 thanks to a mix of functions, which ensures the survival of the buildings as dynamic poles of their municipality.

The study was carried out based on onsite visits and photographic survey of three of the four case studies, the projects' descriptive reports, and interviews to the architects in periodicals and books from the relevant ateliers.

The four cases have as common denominator a less intrusive intervention regarding the existing building, as well as the fact that they allow a greater internal space freedom and versatility. This flexibility provides a better resistance to the passage of time and change of functions, making them sustainable.

Site

The bibliography concerning Odivelas is based mainly on the Municipal Territory Planning, the Municipal Master Plan and Detail Plan, presentations with clarification of doubts made by the Odivelas City Hall, the website of the Odivelas City Hall, as well as site visits, one accompanied by the relevant responsible elements from the City Hall.

The urban project, completed during the 9th semester for the Project Laboratory VI - MIArq subject, was supported, although not entirely, by the following works: *Urban Space*[31] by Rob Krier, *The Image of the City*[32] by Kevin Lynch, *Site Planning*[33] by Kevin

[31] **KRIER, Rob** (1979) Urban Space, Academy Editions.

[32] **LYNCH, Kevin** (1960) The Image of the City, MIT Press, Cambridge MA.

Lynch and Gary Hack, and *The Endless Cities*[34] by Ricky Burdett and Deyan Sudjic. These works were consulted as they provided support in terms of principles and guidelines for elaborating the urban scale.

[33] **LYNCH, Kevin & HACK, Gary** (1962) Site Planning, MIT Press, Cambridge MA and London.

[34] **BURDETT, Ricky & SUDJIC, Deyan** (2008) The Endless City, Phaidon Press Inc.

"We seek to achieve social justice, sustainable economies, and environmental sustainability. Social justice will necessarily have to be based on economic sustainability and equity, which require environmental sustainability. Environmental sustainability means maintaining the natural capital."

Charter of European Cities & Towns Towards Sustainability, (1994)
European Conference on Sustainable Cities & Towns in Aalborg, Denmark on 27 May

3_ SOCIAL COMPONENT

Social sustainability refers to the social equity principle. It can only exist, when equal or greater opportunities and access to social resources are provided in a safe and healthy environment, for both current and future generations (intra and inter-generational equity). These social resources may be from human, labouring and political rights, to other cultures and religions.

The social impact of abandoned properties

Vacant and abandoned properties have a profound impact on its communities, as well as on the surrounding neighbourhoods. According to the *Broken Window Theory*, *"(...) social psychologists and police officers tend to agree that if a window in a building is broken and is left unrepaired, all the rest of the windows will soon be broken."*[35] Derelict buildings have a catalytic effect on its community of more degradation, in addition to attracting dangerous and illegal behaviour. These conditions discourage the investments and maintenance efforts of the community, which creates a vicious cycle with the decrease of properties value. The only way to create stability and reverse the cycle is through rehabilitations, refurbishments or through the demolition in order to build new. By revitalizing, new opportunities and businesses are generated, which will be spread to the surrounding neighbourhoods. As proved by the reference cases presented.

[35] **WILSON, James; KETLING, George** (1989) Making Neighborhoods Safe, Atlantic Monthly, February. (Cited in) **CANTELL, Sophie** (2005) The Adaptive Reuse of Historic Industrial Buildings: Regulation Barriers, Best Practices and Case Studies, Virginia Polytechnic Institute and State University, Master's degree thesis.

3.1_ CREATIVE CITIES

Creativity is to tackle issues in a new and inventive way by the use of imagination. This is not restricted to artists and people involved in creative areas. When the right conditions are created, ordinary people may be the source of broadened creative solutions to address the community's difficult urban problems, or simply create imaginative new opportunities.[36]

The concept of creative city was first mentioned as such by the Ministry of Planning and Environment of Victoria in Australia at a seminar in 1988. However, it was Charles Landry who developed this concept as a new planning theory for cities' development. In 1978, at the same time as UNESCO and the Council of Europe started to study cultural industries, Landry founded "Comedia" and subsequently published *The Creative City: A Toolkit for Urban Innovators.* Other important studies were in the early 1990's the first study of the concept through the city of Glasgow[37], as well as a study on urban creativity[38] in Britain and Germany.

Creative City is an approach based on Landry's idea that *"culture as values, insight, a way of life and form of creative expression, represents the soil from within which creativity emerges and grows, and therefore provides momentum for development."*[39] . However, in order to validate the creative capacity and future of a city the author considers fundamental the existence of seven urban factors (personal qualities; will and leadership; human diversity and access to varied talent; organizational culture; local identity; urban spaces and facilities; and network dynamics). These factors combine therefore soft and hard creative infrastructures. The soft infrastructure refers to the city's mind-set, a force of skilled and flexible work force, dynamic thinkers, creators and entrepreneurs with a strong communication link. The hard, on the other hand, refers to the constructed environment and atmosphere created by the architecture, urban landscapes, landmarks and services that provide and facilitate the dynamism of the community.

The territory is strongly linked to the creative industries that exist in several scales, from creative cities to creative quarters or facilities. This relationship is explored in two contrary territorial-based approaches.

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[36] According to the literature review: **GERSHENFELD, Neil** (2012); **LANDRY, Charles** (1990); **UNESCO** (2004).
[37] **LANDRY, Charles** (1990) Glasgow: The Creative City and its Cultural Economy
[38] **LANDRY, Charles** (1994) The Creative City in Britain and Germany
[39] **LANDRY, Charles** (2008) The Creative City: A Toolkit for Urban Innovators, 2nd edition, Routledge Ed. [online] http://books.google.pt/

The *Creative Industries approach* considers that what causes innovation and development in the creative economy are the creative industries. Which according to John Hartley *"describe the conceptual and practical convergence of the creative arts (individual talent) with cultural industries (mass scale), in the context of new media technologies within a new knowledge economy, for the use of new-interactive citizen-consumers"*[40]. These companies and industries are located as a cluster and benefit from their proximity for the economical development of the area. The clusters combine a mixture of cultural, creative and entertainment companies, which work 24/7 and create collaborations and networks that are favourable to the creative work force. Many of these creative-based facilities were induced by the government aiming to stimulate the identity, entrepreneurship and cultural diversity of the city.[40]

According to this first approach, creative cities were initially associated with the creative industries. However, cities like London, Berlin and New York are considered poles of creativity that attract talent and serve as example to the *Creative Class approach.* The latter approach is based on Richard Florida's book *The Rise of the Creative Class*, and contrary to the Creative Industries, is people-based. It defends that the city attracts through Talent, Tolerance and Technology (3 T's) the creative class, which promotes the regional economic development and the innovation, and consequently becomes more attractive.

In Portugal both approaches were applied. As examples of the first, *the Creative Industries approach,* there are:

- The Lx Factory (presented in the reference cases)
- The New Lx Factory, a project proposed for the refurbishment of an old Convent (more recently a hospital) in Desterro, Lisbon. Due to the success of the Lx Factory complex, this project aims to follow the same principles and contribute to the revitalization of the area.
- The Oliva Creative Factory, a refurbished complex of industrial buildings located in São João da Madeira. It describes itself as a centre for creative competence and excellency, and has as partners the Catholic and the Aveiro Universities, as well as the foundations Serralves and Ricardo Espirito Santo Silva. Their objective is to use the creative community to boost the regional economy. At the same time they create festivals,

[40] HARTLEY, John (2005) Creative Industries, Wiley-Blackwell [online] http://books.google.pt/

conferences and seminars to stimulate their growing community and attract new creative power.

- The new project Estação Central (Central Station), located in Lisbon in an old post office central (refurbishment), which will open in 2013 as a hub of entrepreneurship and creativity.
- Among others.

As examples of the *Creative Class approach,* there are:

- The Paredes: Creative city for Design, which integrates the international network of creative cities. It's objective is to promote specially the furniture design.
- The network of Óbidos, Guimarães, Tondela, Montemor-o-Novo, Montemor-o-Velho and Seia. A network of five cities that have created an association to manage and develop joint projects as artistic residences and entrepreneurship support.

3.2_ CONCEPT OF LIVING LAB, FAB LAB AND COWORK

The *Green Paper on Unlocking the Potential of Creative Industries* states that the cultural and creative sectors need new spaces that translate the fading barriers of work and living and serve the emerging project-to-project style of work from entrepreneurs and freelancers, a growing workforce: *"the setting up of meeting places and laboratories for user-centred and open innovation and experimentation, where various disciplines work together, should be promoted."*[41]

Seija Kulkki[42] defends that a third industrial revolution is happening *"based on convergence of ICT (Information and Communication Technologies) and energy technologies."*[43] At the same time, recently the EU and the OECD[44] published studies where the civil society can contribute to the social, economic, environmental and political renewals.

Considering that technology, modern equipment, space and knowledge are not always accessible to everybody. The fab lab and the cowork concepts attempt to facilitate the access of these commodities to everyone interested. These concepts give the power of entrepreneurship to the community with all the commodities that would come with a company. The community is powered by the technology and support needed and has the opportunity to solve its own problems, boosting the innovation and development.

Living Lab

The Living laboratory model was originally developed by MIT professor William J. Mitchell, of the Media Lab and School of Architecture. The concept was first thought as a user-centric research method of prototypes and multiple innovative solutions in real-life scenarios. Therefore the method evaluates the potential impacts and ensures the development of emerging products and technologies before they are implemented in the market.[45]

[41] Green Paper on Unlocking the Potential of Creative Industries (2010) European Commission, Brussels [online] http://ec.europa.eu/
[42] Seija Kulkki, professor at the Aalto University School of Business.
[43] "Decentralization: Bottom up change. New Economy", Conference Human Habitat 2013: Seija Kulkki, Lisbon, 4 of March 2013.
[44] Organization for Economic Cooperation and Development
[45] **Helsinki Living Lab** (2012) Background: What is a living lab, [online] http://www.helsinkilivinglab.fi/ European Network of living labs [online] http://knowledgecenter.openlivinglabs.eu/

Through the role of networking, communication technologies, social media and a participative society, communities work as crowdsourcing. They contribute not only as subjects (potential users), but also as a work force for the creation, exploration and validation of emerging ideas, innovative concepts and processes. By relying on co-creation and co-production, this model is not viewed as a new occurrence, but mainly as a new awareness to the end-user's involvement.

The Values of the European Network of Living Labs are therefore: Trust and transparency; Human-centricity; Bottom-up, enriching communication; Co-creation and collaboration; and Openness, enabling networking.

An example of a successful international Living Lab is the Mind Lab in Denmark. Christian Bason, the responsible for the MindLab defines it as *"a cross-ministerial innovation unit, which involves citizens and business in developing new solutions for the public sector."*[46]

In Lisbon there's the example of the Living Lab and conferences with public discussion promoted by Construção Sustentável, which promotes an open discussion and serves to further the solutions and innovation in the construction sector.

Fab Lab

The key idea behind the Fab Labs (Fabrication Laboratories) is that each person can create or materialise their ideas when offered informal technical knowledge support and adequate equipment. [47]

The concept was created at Massachusetts Institute of Technology (MIT) in the Centre for Bits and Atoms (CBA) and was inspired in a popular class called "How to Make (almost) Anything" by an investigation group led by Neil Gershenfeld. The group was interested in exploring the physical representation of what was taught in the class, as well as how a community could be powered by the technology. This project was taken to many countries. As MIT states, the project was spread from South Africa to the North of Norway, to rural India and is still expanding. The Fab labs may take different approaches, from non-profit to some that work directly with companies. The projects developed include renewable energy, healthcare and agriculture related technology,

[46] "Design for Growth and Prosperity: Innovation and Design as Drivers of Social Development", Conference Human Habitat 2012: Christian Bason, Lisbon, 1 of October 2012.
[47] Fab Lab (2012) [online] http://fab.cba.mit.edu/

personalised computers and wireless networks, custom intelligent housing, rapid prototyping, among others.

Fab Labs work as a means for everybody to access modern technology and technical knowledge that is not easily accessible and according to the concept "Learn by Doing". The most popular equipment and services are laser, plasma or water jet cutters; 3-axis CNC machines (turning and milling machines controlled by computer) to make furniture and large sized parts; 3D printers to make three-dimensional molds and prototypes; a sign cutter, which creates flexible circuits, masks and antennas; microprocessors and digital electronics design, assembly and test.

This kind of fast digital prototyping labs can create from dollhouses or transformed utensils as an electrical toothbrush into toys for children; to recreating a lost part of an electric appliance; to materializing its own design or equipment idea. For example in a Fab Lab in Ghana oriented by Neil Gershenfeld, an eight-year-old girl was able to build alone in forty-eight hours a wireless house alarm.

According to the MIT[48] there are currently in 2012, hundred and eight working Fab Labs worldwide and twenty-seven more are planned to open in the next few years. In Portugal exist four Fab Labs all associated to innovation and technology: the MIT Portugal; the Fab lab EDP in Lisbon more connected to science; the NOVOTECNA in Coimbra, more directed to health; and the OPOFABLAB in Oporto, which is more focussed in architecture and design.

Even though the Fab labs are usually direct to a certain kind of area, they all follow the same principles. They are open to new projects and ideas, fitting to the supply and demand of the community and evolving accordingly. Due to the understanding and experience with the participants, the knowledge and the projects get more specific to some areas in time. It adapts to the community's specific necessities and due to the diversity of people involved, a network of professional relations and partnerships may be developed. A new dynamic and specialized community is created with a high potential capital. Both socially and economically the investment is justified.

[48] Fab Lab List May 6 (2012) [online] http://fab.cba.mit.edu/

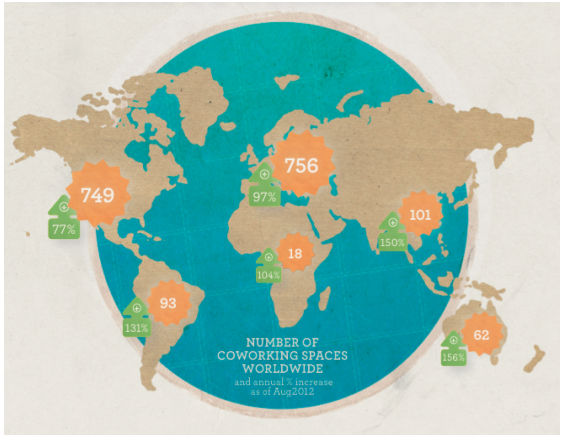

Fig. 3.1 - world map

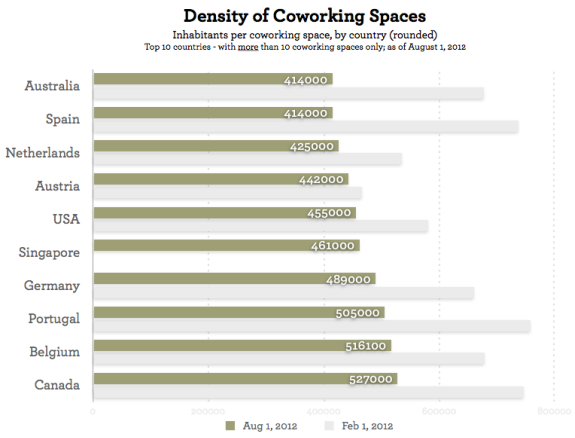

Fig. 3.2 – Coworking spaces in different countries

Cowork

Created to answer to the new problems of flexible types of work, coworking spaces try to combine the best components of different workspaces for freelancers, entrepreneurs or mobile employees from small to large companies. The coworking community is inspired in interdisciplinary spaces, which proved to be a catalyst to innovation, development and the increased capacity and quality of intellectual work. These spaces combine the flexibility of a home office with the social aspect of working in a cafe. At the same time as they promote the collaboration and community network building as happened in the Coffee House Culture or the Gentlemen's Society. Thus, its definition should not be based on organisational or spatial characteristics, but on its function and work concept.[49]

Nina Pohler[50], in her thesis on the topic of coworking, at the Vienna University for Business Administration and Economics, defines it as: "*Every workspace with flexible structures that is designed for and by people with atypical, new types of work - that is not exclusively for people from one certain company.*"

The technological developments, as the laptops, mobile phones and wireless internet access, combined to the increased outsourcing for projects or part of the work, and the globalization of the companies, has permitted an increase of flexibility in the workforce. Many of the old structured companies can't compete with the quick response to new tendencies and technologies, as provided in the market by the increase of specialised freelancers. Companies can however benefit from an improvement in the business efficiency by adopting more flexible work models. Big companies like Google are starting to take interest in the concept, sponsoring coworking spaces like the TechHub in London to promote the exchange of ideas.

In 2010 was carried out a web survey concerning teleworking by CompTIA (Computing Technology Industry Association) to 212 companies of different sizes in the United States, Canada and the Great Britain. This survey showed that when given the opportunity to telecommute, the workers had an increase of productivity and skills, a reduction of costs as well as a reduction in health problems. These freelancers and entrepreneurs, with their employees, are the main users of the more than 2000 cowork spaces worldwide (Fig.3.1), which represent an increase of 250% comparing to the 2010 numbers.

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[49] According to the literature review: **DESKMAG** (2012);**COWORK Lisboa**, (2013);**POHLER** (2011);**PEREIRA** (2012)
[50] **POHLER, Nina** (2011) Coworking 101: A new definition, [online] http://www.deskmag.com/

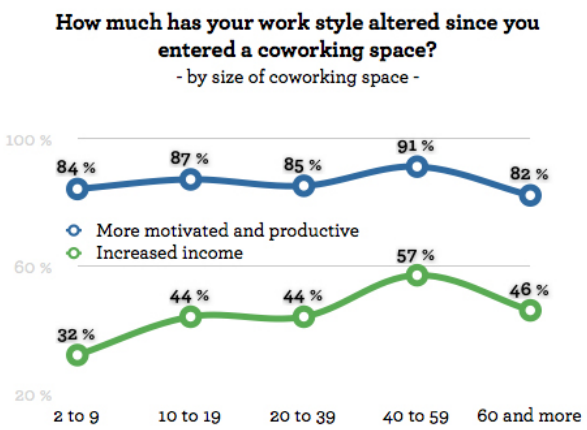

Fig. 3.3 – Work style of coworkers

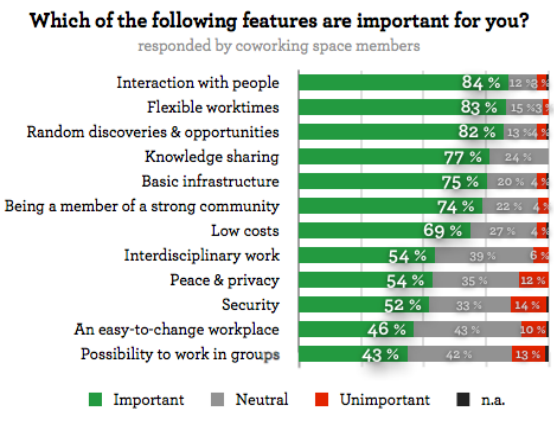

Fig. 3.4 – Important features for coworkers

The work style and the projects of the coworking community determine the demands. Though, the common basic demands are an equal amount of permanent and flexible tables, meeting rooms, basic office supplies and equipment, a small kitchen, wireless Internet and in most places a demand for a 24/7 working space. (Fig.3.4).

Portugal has currently, in 2012, 38 cowork spaces, 18 in the Lisbon District,[51] most of which opened this year.[52] This tendency relates to the increase of demand for such spaces in Europe for the last two years.

The advantages and benefits of coworking spaces proved to have a high impact on the local economy and community as it:

- Optimizes the use of space, equipment and services;
- Creates a network for collaborative partnerships and consumption, through the exchange of professional expertise from different areas. This creates not only economic links, as well as social and psychological support to overcome demotivation and creative blocks; (Fig.3.3).
- Retains talent within the city, which allows the professionals to work in their area of expertise and contribute for their local economy;
- Helps support small businesses and brand development.

[51] [online] https://www.deskwanted.com/
[52] **PEREIRA Micael**, (2012) O Meu Escritório É Teu, Expresso Newspaper, 17 November.

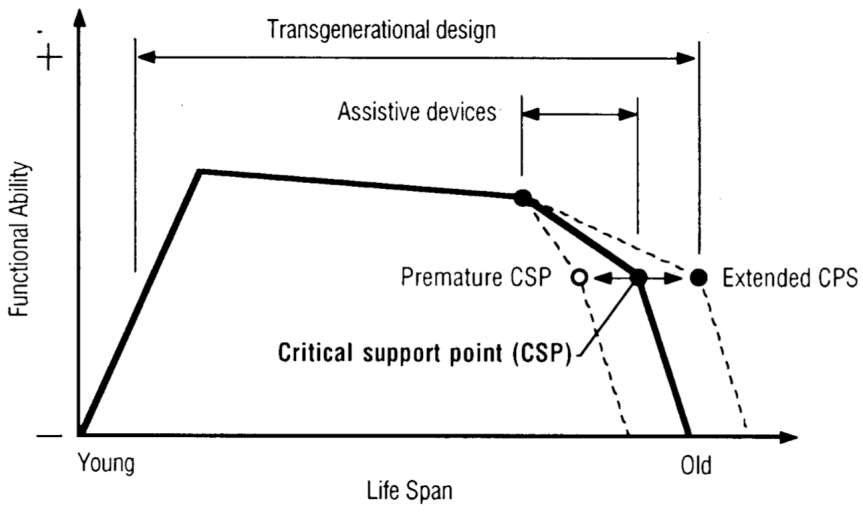

Fig. 3.5 – Transgenerational Design as a means to extend independence.

3.3_ UNIVERSAL/TRANSGENERATIONAL DESIGN

Owed to the evolution of the technology and life conditions, our century is marked by a low mortality, low nativity and long life expectancy. According to Portugal's Census Population Projections, in 2011 approximately two millions of people were 65 years old or older (20%) and in 2050, that number is expected to double.[53]

The urban and housing designs must be able to accommodate this increasing percentage of the population, instead of limiting their independency and self-sufficiency. With this objective in mind James J. Pirkl has developed the *Transgenerational Design* (Fig. 3.5). This project studied in detail the aging process and created a set of guidelines, which would tackle the accessibilities issues and include strategies to overcome the physical and sensory impairments, as the declining eyesight and hearing. Some examples of features are wider doors and corridors, dual-height balconies, task lighting as well as non-glare and non-slip floors, among others.

At the same time, motivated by the disability rights movement, the architect Ronald L. Mace coined the term *Universal Design* as a concept that would go further than the *Accessible and Barrier-free Designs.* This concept would create strategies and principles that when followed would promote the creation of products that could be used by everyone. The seven principles are:

1. Equitable use
2. Flexibility in use
3. Simple and intuitive
4. Perceptible information
5. Tolerance for error
6. Low physical effort
7. Size and space for approach and use.

[53] **DuJardin, Marc** (2011) class on social sustainability, Saint-Lucas Hogeschool voor Wetenschap & Kunst, Gent, Belgium.

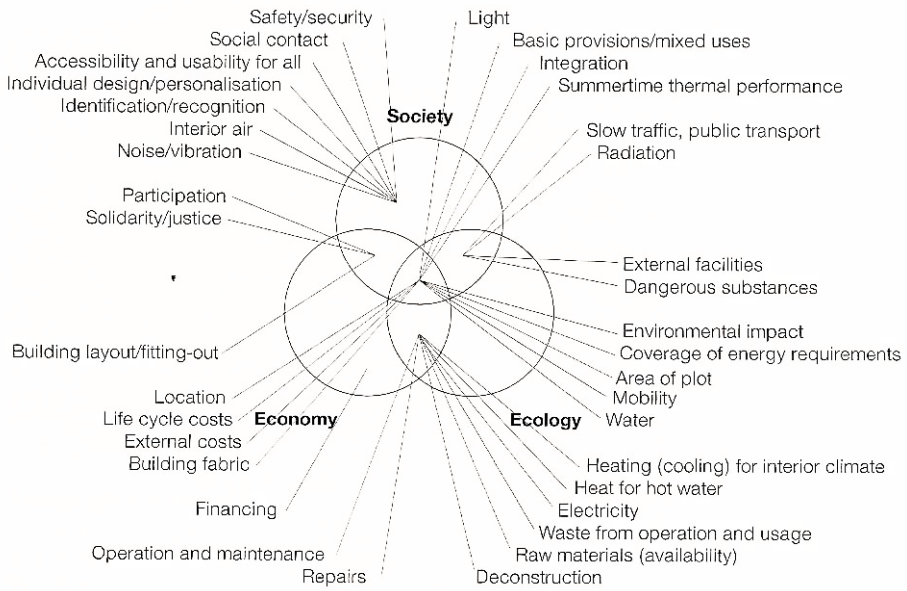

Fig. 4.1 – Scheme of the three components

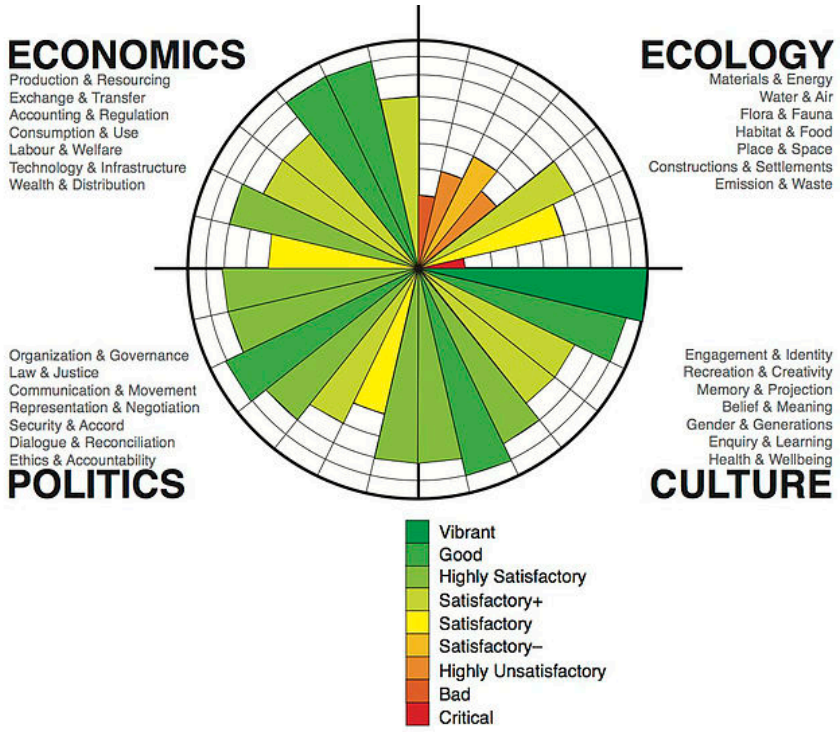

Fig. 4.2– Circles of sustainability – assessment of the city of Melbourne 2011

4_ ECONOMIC COMPONENT

In order to be sustainable, to function for a number of years maintaining the quality level, an economic system must accommodate the ecosystems and resources it depends on.

The International Resources Panel[54] in 2011, at the UN, stated that the human race could be increasing in three times its current consumption rate of fossil fuels, ores, biomass and minerals by 2050. As demonstrated by the numbers of population and economic growth and the associated environmental qualities, as well as the study performed by this report, the growth of the economy is usually associated with an impoverishment of the environment. The study of the report realised a comparison between developed country, where the consumption would be on average 16 tons of these four resources per capita, per year, and an underdeveloped country as India, where the consumption was 4 tons.

Economic sustainability is, since the Brundtland report, associated with the social and environmental sustainability through its activity's consequences (Fig.4.1). It is linked to the social aspect through the population's consumptions and demands, and to the environmental aspect through the consumption of resources and consequent ecological degradation. This global approach's assessment is being applied to cities (Fig. 4.2). Due to the inclusion of the other components, it allows a comparative evaluation of all fields, as well as a better understanding of their relation and interaction.

The term of economic sustainability is therefore associated to a set of actions, taken in the present, to ensure a responsible and efficient use of the resources.[55] With these principles it is possible to provide a consistent quality, wealth, welfare and levels of consumption in the long-term for the future generations. As opposed to the pressure on the environment caused by the conventional economy, which generates a decrease in quality of life and results in an *uneconomic growth*. In order to maintain and manage the quality of life of developed countries and at the same time improve the quality in developing countries, it is imperative to combine strategies of economic management and product design in addition to technology. For example, it is possible to increase the

[54] Decoupling: natural resource use and environmental impacts of economic growth, (2011) International Resource Panel report [online] http://www.unep.org/resourcepanel/
[55] According to the literature review: **RYPKEMA, D.** (2007); **NEMETZ, P.N.** (2003); **ROMBAUT, E.** (2011); **AAVV** (2001); **HEGGER, M.** (2008); **KONING, H.** (2010); **PINHEIRO, M.** (2006); **UN** (1987); International Resource Panel report (2011).

investment and the long-term viability of an operation via strategies as the use of environmental friendly materials, the design of waste disposal and recycling strategies, energy efficiency to reduce costs, among others.

"(As) a commodity or service becomes more scarce the price increases and this acts as a restraint that encourages frugality, technical innovation and alternative products."[56] To turn the ecosystems into commodities in the market were created several market tactics. For example legal benefits as tradable permits for carbon, monetary benefits as incentives and Eco taxes and marketing benefits from an enriched public image.

To allow projections for the future as well as certify to the correct management, it is important to provide a set of measurement systems. These systems comprise indicators; certifications like Fairtrade and organic, or in a larger scale like LEED, BREEAM and in Portugal LiderA; report systems; benchmarks and audits. The best known systems consist in the Triple Bottom Line accounting, Sustainability and Environmental Performance Indexes, corporate reports of the generated return in monetary currencies, the Millennium Ecosystem Assessment, the Ecological Footprint that measures the resources needed for the demands and the absorption of the waste, and the Carbon Footprint, which quantifies the emission of greenhouse gas.

[56] **Nemetz, P.N.** (2003) Basic Concepts of Sustainable Development for Business Students, Journal of International Business Education [cited in] http://www.wikipedia.org

4.1_ ECONOMIC DEVELOPMENT OF CREATIVE CITIES

Even though cities have always been considered the core of economic growth and culture, it's a recent idea that culture and creative industries can work as urban regenerators. The strong social and cultural infrastructure branches to other local economies as agriculture, gastronomy, handicrafts and tourism, which boosts of the economy, and creates cultural diversity, as well as new jobs.

UNESCO states, *"Creative city schemes (...) have proved to be innovative new ways to promote social and economic development and stimulate new enterprise and cultural diversity in struggling and well as prosperous city communities."* [57] Accordingly, in 2003 the culture and creative sector corresponded to 3,1% of the total employment of the European Union and generated 654 billion euros, which corresponds to a 2,6% GDP[58] of the European Union. With these values, the sector had a growth of 12,3% since 1999, higher than the global economy growth. Since the crucial resource of these approaches is the skilled workforce, the most innovative cities with the fastest growth are the ones with a higher human capital. This is shown by the Florida's Creative Class Index realized in 2000, where countries like the United States (30.8%), Belgium (29.97%), the Netherland (29.8%) and the United Kingdom (26.73%), among others, had higher percentages of their national workforce in creative occupations than for example Portugal and Italy, with less than 15% and with a negative growth.

Considered the most successful creative centre in the new economy, Silicon Valley in California intends to stimulate the vitality of the area and its creative potential by introducing such projects. Through the creation of public-private partnerships, the industries, the government and the non-profit sector help promoting creative-based strategies.

[57] (2004) Creative Cities: promoting social and economic development through cultural industries, UNESCO, November.
[58] Gross Domestic Product, which is equivalent to the Portuguese PIB.

4.2_ ECONOMIC IMPACT OF REHABILITATION

Rehabilitation is a crucial part of smart growth planning and sustainable development according to the economics principal Rypkema[59].

Rehabilitation may serve as an economic strategy due to its catalyst effect on the revitalization and development of the area involved and through the creation of new jobs and revenues. Furthermore, even if the rehabilitation or refurbishment works and expertise are more expensive, the total cost of construction, according to Appleton[60], may be lower than one from a new building. This occurs owed to the reduction in demolition and licenses costs, and to the reduction in the amount of materials necessary, among others.

The private sector can work more efficiently in producing the redevelopment of vacant properties. However, these projects are more successful when integrated in a thought master plan. Through a neighbourhood or a building complex, the rehabilitation may trigger the growth of the surrounding areas. Some examples as the Lx Factory in Lisbon (presented in the reference cases) have served as a dynamic source of revenues to a previous abandoned area of the city.

In order to attract these investors to the derelict properties, the government offers financial incentives and fiscal benefits. The financial incentives created by investment funds as RECRIA[61], RECRIPH[62], REHABITA[63] and SOLARH go from 20% of the total cost, plus 10% in case it is required by fire and safety norms, to a full costs interest-free loan. However, these incentives are only applied to housing buildings. The recent initiative JESSICA, in contrast, stands for the Joint European Support for Sustainable Investment in City Areas and allows the use of FEDER's fund[64]. This fund, through the Portuguese FDU, Funds of Urban Development, intends to support the sustainable rehabilitation of urban areas and promote urban development. In addition to these incentives the government implemented fiscal benefits that attract private investors as a reduction of 30% in the IRS (to the limit of 500€) and an exemption of the IMI (Municipal Housing Tax) for a five-year period, among others.

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[59] **RYPKEMA, Donovan** (2007) Sustainability, Smart Growth and Historic Preservation, SOHO Annual Conference, May, California
[60] **APPLETON, João** (2010) VI ENEEC – Encontro Nacional de estudantes de Engenharia Civil, Évora, Abril.
[61] (Special Regime of Contribution in the Recuperation of Rented Housing)
[62] (Special Regime of Contribution and Financing in the Recuperation of Urban Buildings in Horizontal Property Regime)
[63] (Support Regime to the Housing Recuperation in Old Urban Areas)
[64] (European Regional Development Fund)

As non-income related incentives, the City Halls could offer bonuses of density, waived development exactions or waived parking requirements, as an alternative. These and similar incentives, specific to each project, would benefit the investors without having to rely on public funds.

With the growing incentives and support, rehabilitation can act as an opportunity to qualify the existent buildings. It regenerates and creates comfort and economic conditions by maintaining and revitalizing the identity of the place.

5_ ENVIRONMENTAL COMPONENT

In order to achieve environmental sustainability, society must balance the activities that answer its needs with the indefinite preservation of the planet's life support ecosystems. Therefore, the consumption of resources must be according with their carrying capacity.[65]

When this balance isn't achieved, resources and ecosystems are explored to the extreme of not being able to replenish naturally. The consequence of deforestation for example, doesn't involve only the exhaustion of a raw material resource. As many environmental resources it is intertwined in an ecosystem. It has an impact through the maintenance of biodiversity, the regulation of water flow to prevent floods, as well as through the conversion of CO^2 in oxygen.

The *Millennium Ecosystem Assessment*[66] states in its study that humans are already living beyond the carrying capacity of the planet. The means of achieving a balance is through an environmental management associated with a resource and demand consumption management. In the first case, the environment management may act in many scales: From the control of the atmosphere, by the assessment of the carbon cycle, related to a climate and biodiversity change, as well as the air pollution that creates smog, acid rain and contributes for the degradation of the ozone layer; to the management and treatment of fresh water (2,5% of the world's total); and to the land use, which comprises natural capital from rainforests to urban gardens. The second case, the management of the demands and consumption of resources acts in the reduction of consumption associated to a continuous cycle of production, use and disposal that transforms, as much as possible, the waste of one activity in the resource of another.

From a consumption point of view, it is the life style associated activities that create higher impact in the consumption levels.[67] The fossil fuels used for mobility and household consumption were once the major drivers of technology and source of economic and political power. Now, their use and associated life styles, in a growing population, must be controlled in a way to reduce the CO^2 levels.

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[65] **LECHNER, Norbert** (2008) Heating, Cooling, Lighting: Sustainable Design Methods for Architects, Wiley.

[66] **Millenium Ecosystem Assessment** (2005) Ecosystems and Human Well-being: Synthesis, Island Press, Washington, DC. [online]. http://www.millenniumassessment.org/documents/document.356.aspx.pdf

[67] "Curso de Construção Sustentável – Acreditação dos Assessores do Sistema LiderA", ITeCons, Coimbra, 25 and 26 of September 2012.

According to the IPAT formula, which portraits the human consumption, the environmental impact is measured by the relation between the Population with their levels of consumption (Affluence) and the Technology used. (I=PxAxT) Since the sustainable development is based on social equity, a technology that allows an intelligent production and use of energy, as well as a carbon neutral life-style, is a key element for the sustenance of the environment.

The search for low environmental impacts and sustainability involve a large number of criteria, which are interlinked and contribute for a better performance and use of the buildings. Based on this, the LiderA certification presents environmental and socio-economical parameters. The environmental criteria is divided in three groups (Local, Resources and Loads), organized as following:

Site and Integration	Resources	Environmental Loads
- Soil	- Energy (includes the technology and passive and active strategies)	- Wastewater
- Natural ecosystems	- Water	- Atmospheric emissions
- Landscape	- Materials	- Waste
- Amenities		- Noise emissions
- Accessibility		- Thermal and light pollution

Each criterion combines several principles, which influence the design decisions. Criteria as the materials and the energy – through the passive and active systems implemented - represent a specific direction, morphology and constraints in the design. Therefore, in order to achieve efficiency in and between the criteria, systems, and solutions, it is indispensible to analyse them in all their life span (the Building's Life Cycle Assessment).

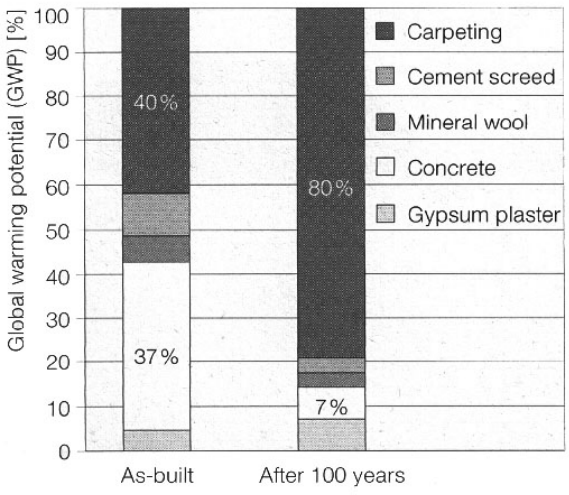

Fig. 5.1. Global warming potential of a pavement with carpeting

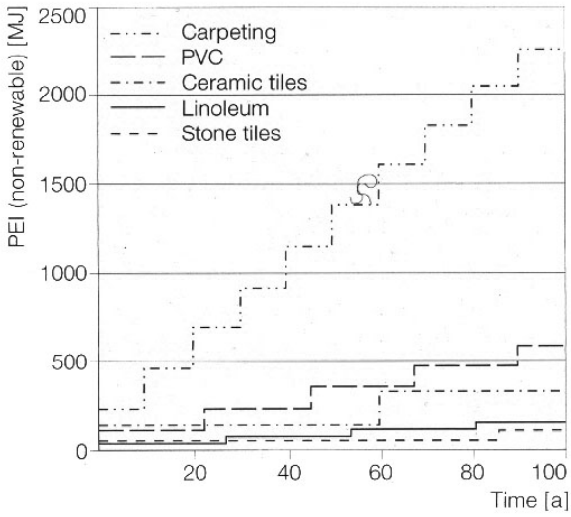

Fig. 5.2. Embodied energy of pavement coverings

5.1_ BUILDING'S LIFE CYCLE

In the first century, Vitruvius[68] named Strength as one of the three main and most important characteristics of a building (beauty, utility/function and Strength/resistance). Buildings due to their longevity are a testimony of human development and its cultural, physical and economic capital. Buildings are built to last and in old ones it is common to find components that have different styles because they belonged to other buildings. The materials or components were re-used owed to their quality and shortage. Due to the different service lives of building components the energy requirements differ during the building's life cycle. Some elements even though they have lower embodied energy, must be replaced more often, or need more maintenance. This contributes to a higher embodied energy in the building's life cycle (for example in the choice of the pavement coverings - Fig. 5.1 and 5.2). Therefore, the life cycle analysis of a building is key to choose materials and building processes, in order to reduce the use of resources and minimize its embodied energy.

A building's Life Cycle comprises its whole time-span and presents a specific planning, strategy and action for each phase (initiation; planning; realization; usage and closing). The analysis extends from the extraction and processing of the raw materials to their recycling or disposal, allied to their environmental effects. There are two diverse methods. One based on the material required inputs and the other based on these environment effects. The first one was introduced in 1994 and consists in a sum of all the component's material inputs for both producing and using. This instrument is called Material Input Per Service unit (MIPS). The second one, the Life Cycle Assessment calculates the emissions of building materials, elements and function layers. Along with this assessment, the Life Cycle Costs is a "cost-optimized building planning"[69] approach. This approach has a potential of savings of 10% of the total costs.

The interest in usage and maintenance costs is increasing by promoters and investors. This obliges to a higher quality construction and sustainable strategies that reflect in the total cost of the building, as opposed to a thinking focused on the initial investment. As a means to ensure the compliance of these premises, there is a growing demand for instruments as certifications, which allow comparisons and classifications. The first and one of the two best-known certifications is the BREEAM, which was

[68] **VITRUVIUS POLLIO, Marcus** (2001) Ten Books on Architecture, Cambridge University Press
[69] **HEGGER, M., FUCHS, M., STARK, T., ZEUMER, M.** (2008) Energy Manual: Sustainable Architecture (Construction Manual), Birkhäuser Architecture.

Table 5.1. Basic features from different certification schemes (Adapted[70])

	BREEAM	LEED	LiderA
Year Launched	1990	1998	2005
Country	UK	USA	Portugal
Information Gathering	Design / Management Team or Assessor	Design / Management Team or accredited Professional	Design / Management Team or Assessor
Assessment	Licensed Assessor	USGBC	Acredited Assessor
Third Party Verification	BRE Global	N/A	N/A
Certifying Body	BRE Global	USGBC	LiderA
Number of Criteria (Current version)	67 Criteria from 8 Categories: - Management - Health and Well Being - Energy - Transport - Water - Materials - Land Use - Pollution	41 Criteria from 6 Categories: - Sustainable Sites -Water Efficiency - Energy and Atmosphere - Materials and Resources - Indoor Environmental Quality - Innovation and accredited Professionals.	43 Criteria from 6 Categories: - Site and Integration - Resources - Environmental Loadings - Environmental Comfort - Socio-economic Experience - Sustainable Use Conditions
Rating Scale	Pass | Good | Very Good | Excellent | Outstanding	Certified | Silver | Gold | Platinum	C (25%*) | B (37,5%) | A (50%) | A+ (75%) | A++ (90%) (*% of improvement from common practice (E))
Number of Units Certified	> 100 000	> 20 000	>1200 flats and > 6000 beds

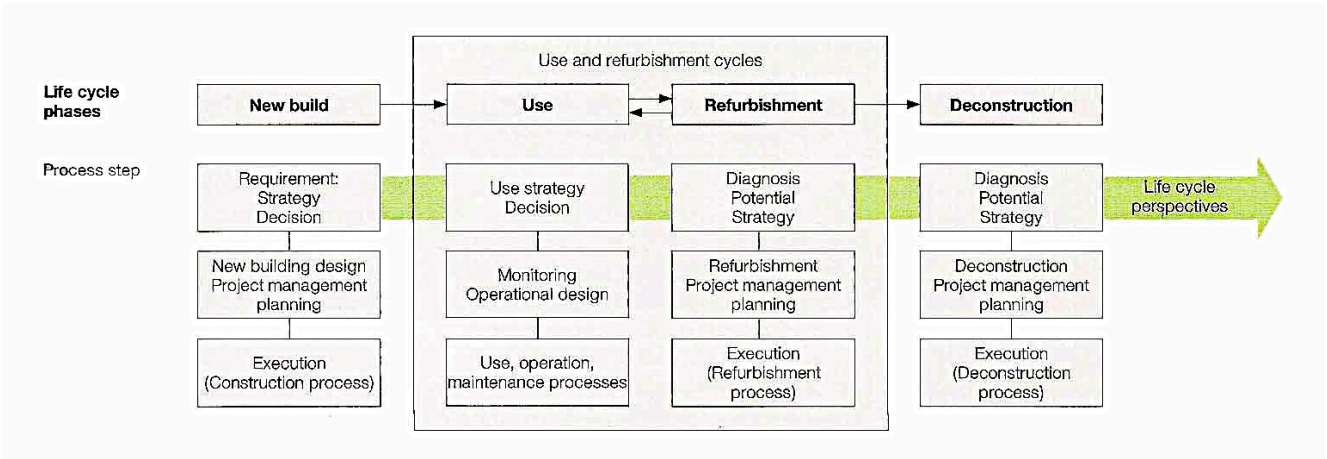

Fig. 5.3. Life cycle phases and process steps

[70] **KONING, H.; KOHLER, N.; KREISSIG, J.; LUTZKENDORF, T.** (2010) A Life Cycle Approach to Buildings: Principles, Calculations, Design Tools, DETAIL Green Books.

introduced in the United Kingdom in 1990 and stands for Building Research Establishment Environmental Assessment Method. Along with the LEED (Leadership in Energy and Environment Design), certification launched in the United States in 1998, these certificates provide several versions, according to the type of building and the Continent. In the process of certification there are two distinctive approaches. The first one, implemented by BREEAM is a ranking based on a list of principles to be fulfilled. The second one is an approach based on the accountability of methods and processes used, allied to their foreseen effects on the environment, economy and society. These analyses involve many fields, from the materials, to the energy, costs and constructive processes, among others. To meet these diverse building sectors exists a wide range of tools and approaches:

- Analysis and simulation software as the Ecotect or the Energy+;
- Labels and certifications for processes and materials;
- Reports of environmental strategies;
- Costs and Impact analyses.

In order to better assess, other countries started to create their own green assessment system, in accordance to their specific characteristics, as regulation, economy, and climate zone. Some examples are the CASBEE from Japan, the GREEN STAR from Australia and the LiderA from Portugal. These national certifications, though not so known world wide, are proving to be more efficient choices for national buildings. Thus they are the choice of big international franchises as the McDonalds. Though, to better serve the market an effort still has to be made to provide and equivalence method between the certifications. For they provide market incentives for the implementation of the sustainable development principles and create a database for research and application. In the last years there has been an evolution in these evaluations. Instead of focussing in the construction or the operations, these analyses started to approach the building's life cycle.

The activities during the life cycle of buildings are defined by the phase the building is in, and comprise distinctive levels of planning strategies and actions (Fig.5.3). In Portugal, as in many countries, there is a broad amount of buildings that are degraded or functionally inadequate. Therefore the refurbishment is an important aspect to prolong the building's life cycle, while assuring the current needs, safety measures and comfort. The refurbishment phase actions may focus on the whole building or only in some components. This way, the process involves three strategies: the value conservation strategy, the planning of the works management and the actual

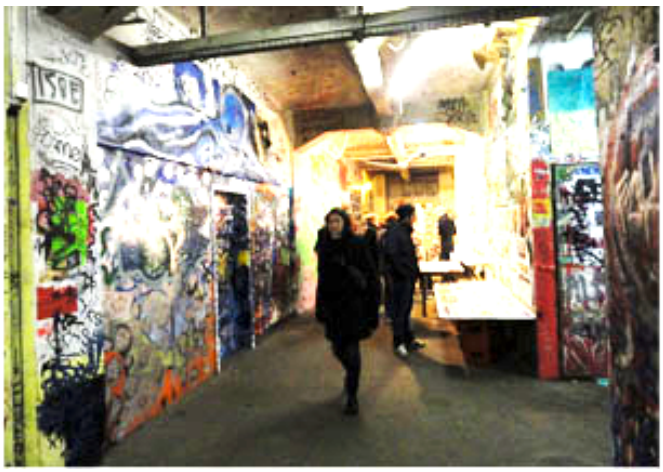

Fig. 5.4. Tacheles, Berlin

Fig. 5.5. Crew Hassan, Lisbon

refurbishment action. The first strategy, the building's value conservation, implies the maintenance of the original use by improving the comfort levels for a better response to the service's requirements. The second strategy, the planning of the works management, begins with a diagnosis of all the elements' conditions. This diagnosis comprises information from the degradation levels to the access possibilities and buildings occupancy rates. From this arises some refurbishment measures associated with the expected long-term potential of the building. The last strategy is conciliating these measures with the occupation of the still active building.

Refurbishment of Industrial Building Complexes

On a life cycle aspect, industrial obsolete and derelict buildings, particularly large complexes are appropriate to mixed-use developments. The pedestrian friendly site plans, as well as the variety in building types, function and sizes, makes them flexible. In addition, due to their proximity to the city's centre with good infrastructures as well as the raise in price per square meter of urban soil, these buildings start to be increasingly reconverted or rehabilitated.

The industrial patrimony criterion, according to the DGPC, the Directorate General for Cultural Heritage, is based in architecture, artistic, historic and technological criteria, established for each building in reports from specialists from many fields. This procedure applies a specific and distinct law to each building, which translates into a long process. An example of a building protected by this status is the Cordoaria Nacional, considered one of the longest buildings in the world and it is a witness of a time when Portugal was a maritime power. This space was adapted and transformed in an exposition and events space.

Certain abandoned buildings due to their character and particular identity are illegally occupied and in many cases transformed into dynamic cultural sources. Due to their success, these buildings start to be promoted by entrepreneurs and entertainment industries. Some examples are Tacheles in Berlin (Fig. 5.4) and the Crew Hassan in Lisbon (Fig. 5.5). Kunsthaus Tacheles was originally a department store in the Jewish quarter in Mitte, Berlin. The building had many consequent uses and adaptations until 1990, when after the Berlin Wall's fall it was occupied by artists. Its name is from the German/Hebrew expression "tacheles reden", which means to state one's opinion, straight talking. Even though it was occupied by roughly 60 squatters, the building contained a nightclub and a cinema in addition to the artists' "galleries" and studios.

Although Tacheles was emptied and closed by the owner in September 2012, the renowned name and concept was taken online as the Tacheles 3D Online Art Gallery. This proved the importance the building had for the creative community. The Crew Hassan, on the other hand was posteriorly bought by a entertainment franchise and was kept with the same spirit.

When obsolete, if the building doesn't meet the industrial patrimony criteria, isn't visually appealing or of historic or cultural interest, gets demolished. Namely, when the function destined to the degraded building is different from the original one, the entrepreneurs tend to prefer a building typology that promotes profit and is optimized for the intended function. Also, many industrial buildings continued open, though minimizing their maintenance and letting the buildings degrade, which led to even higher repair costs. All these circumstances foster the full demolition of the building to allow a new one.

The construction of a building requires great amount of energy. Through the use of machinery, the materials' transportation and the embodied energy (the primary energy input from its production, maintenance and deconstruction/disposal). The building's embodied energy of for example a modern office building, according to Norbert Lerchner[71], *"is about the same as the amount of energy the building will consume in fifteen years."* When refurbished or adapted much of this energy can be saved. For example, by reusing a 10 000 square foot industrial building (approximately the site area of the case study) 9,7 million MTBUs[72] of embodied energy are saved. This value associated with the 155 MTBUs that would result from its demolition[73], prove that the refurbishment of such buildings is the sustainable decision.

According to People & Business magazine, in it's article *Making Spaces: Experiencing the past with modern comforts*[74], *"Portugal has a collection of industrial buildings that were built in an era of stability, when buildings were expected to last for generations. How to sympathetically convert such good quality construction with the design features of the past, poses interesting challenges for today's architects."*

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71 **LECHNER, Norbert** (2008) Heating, Cooling, Lighting: Sustainable Design Methods for Architects, Wiley.
72 MTBUs are a standard unit of measurement. It stands for Million British Thermal Units. (3412 BTUs = 1 kWh); (1 BTU = 1,055.06 joules). Information from the energy dictionary [online] http://www.energyvortex.com/
73 Embodied Energy Calculator. Value estimated for heavy construction (masonry, concrete) industrial buildings. [online] http://thegreenestbuilding.org/
74 Making Spaces: Experiencing the past with modern conforts, People & Business magasine (Setembro 2009) [online] http://www.lxfactory.com/PT/imprensa/

5.2_ TECHNOLOGY AND STRATEGIES

The building's energy consumption and its activities have a great environmental impact due to the current life style's energetic demands, especially in urban areas. As a reference, in the United States of America the buildings use 48% of the consumed total (40% for the functioning and 8% for the construction)[75]. In Europe the values in the residential and tertiary sector are over 40%[76], while in Portugal they decrease to 30%[77].

In terms of energy, the operation phase of a building has a significant weight in its life cycle. Since each phase's options will have repercussions in the following ones, this phase must be considered, when making decisions for the others. Therefore, a higher energy demand in the construction phase can be justified, if it results in a diminished energy requirement in the longer phase of operation. The previous higher cost is compensated in the total energy balance.

In addition, it is in the operation phase that it is possible to generate higher reductions in consumption. It can rise in average up to 80% of a building's total energy use. This reduction can be achieved through strategies and techniques adopted in the conception phase of the building.

These strategies and techniques aim at that minimization of consumption, and can be structured in three levels, according to their nature: architectural design of the building; efficient natural energy processes; and the choice and use of the equipment.

However, the principles and actions inherent to the sustainable design strategies become harder to implement in a refurbishment phase, given the associated restrictions. Nevertheless, they can and should be a priority and the core of what the building's interventions should be. These strategies allow the prolonged existence and functionality of the building. It becomes more flexible and efficient regardless of its pre-existences or the size of the intervention.

The use of the sustainable design premises (level 1) is based on heat transfer principles, matter and energy interaction, as well as heating, cooling and lighting approaches. These strategies, implemented in the conception of the building's intervention, allow a reduction up to 60% of the average energy consumption in the operation phase. At the same time, it is possible to achieve savings of 20% with strategies based on the efficient use of natural energy resources (level 2). In addition,

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[75] **LECHNER, Norbert** (2008) Heating, Cooling, Lighting: Sustainable Design Methods for Architects, Wiley.
[76] **Parlamento Europeu e do Conselho** (2002) Directiva 2002/91/CE, December 16.
[77] **Direcção Geral de Energia** [online] http://www.dgeg.pt.

the adoption of efficient equipment (level 3), can reduce the building's energy loads in 8%. If all of these measures are applied correctly and all the maximum reduction values are achieved, the total energy consumption is 12% of the common practice value. Furthermore, this energy load can be supported by renewable energy sources in the building itself or in the surroundings (level 3)[78].

The thermic level of comfort is reflected directly in the energy use during the functioning of the building. The more the building is adapted to its climate and location, the less the interior comfort will depend on mechanical equipment. Thus, characteristics of the location, as the ambient air temperature, air velocity and relative humidity, are extremely important in the heating and cooling concept of the building.

The objective is therefore to achieve a thermic equilibrium for a comfort setting. This should be achieved without high energy demands; by profiting from natural resources; by avoiding big temperature differences in the interior of the building; and via the use of the location's characteristics, which are obtained through efficient materials, efficient lighting, air quality and water use, as well as through passive and active systems.

5.2.1_ MATERIALS

Materials are of great importance in the health and hygiene conditions of buildings, as well as in its behaviour with the environment. They condition the use of the space and the supplementary requirements during the building's life span. The material's technical and function performance dictate their life cycle and durability.[79]

Therefore and according to this new awareness in addiction to political demands, we face times when due to the technological development and the globalization, more construction techniques and materials are available. At the same time, there is an increased study of the vernacular architecture with its techniques, low or inexistent machinery, local materials and passive systems. Constructive techniques and the use of materials like the adobe, among others, proved to be methods with ideal

[78] **LECHNER, Norbert** (2008) Heating, Cooling, Lighting: Sustainable Design Methods for Architects, Wiley.
[79] (2011) Study Trip To The Netherlands: The exhibition on sustainable building materials VIBA-Expo and the EVALanxmeer Ecoquarter, Environmental Sustainability class, Professor Erik Roumbaut, Saint-Lucas Hogeschool voor Wetenschap & Kunst, 7 June, Gent, Belgium.

thermic and acoustic behaviours, as well as their durability, fire resistance and their possible reutilization without toxicity or the production of waste.

A responsible choice of building materials should look at the ecological and energy related effects, for example through the material's embodied energy (or grey energy - the primary energy input from its production, maintenance and deconstruction/disposal). Some important analyses in the field of the materials are according to the Staircase of Lansink (a list of the best to the worst solutions in dealing with waste) and the most complete, the life cycle analysis. These criteria allow the comparison with alternatives to products with a negative impact both on the environment and the human health. The information is beginning to be available to general public through: expositions as the VIBA-expo in Hertoghenbosch; through labels as the *Forest Stewardship Council*; declarations as the *Environmental Product Declaration*; information systems as WEBCOBIS; element catalogues as *Green Guide for Specifications*; in online databases as the German's *Okobau.dat*; software as the *Greencalc* or scaled indexes as the *Miliew matrix index* (scaled from 1 to 7), among others. Some examples of alternatives to non-sustainable materials are:

- Greed, created from the materials of demolished buildings, that can be used for concrete production;
- Non-baked bricks, which have a lower ca.;
- Silicaatsteen, for inside applications;
- Natural based paints, because the most common carry poisonous pigments and toxic solvents, that by evaporating are associated with summer smog;
- Linoleum;
- Termosheets insulators;
- Stroleem, straw and loam compressed, construction;
- Wood with the Forest Stewardship Council label;
- And many more alternatives to construction, heating and cooling.

Products like pvc that aren't biodegradable became popular in the construction business. However, as studies prove, it is not poisonous only in the end of its life cycle due to being incinerated. During its life cycle it releases dioxins through evaporation. (These dioxins though in small amounts, have been associated with the increasingly common breast cancer disease.) In addiction, despite the fact that pvc companies state that it's possible to recycle it, owing the fact that 1/3 of pure pvc has to be added to

maintain the material's quality, this process results in Down cycling instead. Not only alternative products like ceramics are healthier solutions for both the environment and people, but also they are already part of our vernacular architecture, of our culture and tradition.

Even though these alternative products were proved to have considerable advantages over the others, economically they are not able to compete with the standard industrialized ones. In Scandinavia as a means to make these products more accessible, an Eco tax was created. Since it was difficult to brake the cycle of higher costs and consequent less production of eco-friendly products, the Eco tax would be applied to the other products. This strategy helps to create more choices in the market, support the environmental-friendly production, and at the same time put the responsibility of associated environmental costs in the hands of the producers. This leads to a Bio-ecological building design in the future practice.

A better relation between the building and the environment, along with the balance between economic, social and environmental sustainability, is supported by the combination of the use of raw local materials, the minimization of waste and mechanical use throughout the whole process, the maximization of recycling and re-use of materials, in addition to the better use of natural resources through passive techniques.

5.2.2_ PASSIVE AND ACTIVE SYSTEMS

Passive systems, as well as passive design strategies, use only ambient energy sources. Therefore, the site and climate of the building exercise a big influence on these strategies, which include daylighting, natural ventilation, solar and wind energy, water management and treatment, among others. Through constructive elements or integrated components, it is possible to use these natural resources for heating, cooling and lighting the building's interior to a comfort level. However, the success of passive systems depends in a large scale on the building's orientation; geometry; mass; shading and surrounding elements; as well as its insulated envelope, among others. In order to guarantee an efficient combination of systems all-year round, the choice of which system to adopt is a result of the balance between the needs and loads in the winter with the ones in the summer. For a natural heating system in the winter may lead to

overheating in the summer. Therefore, the systems must be thought for the whole year.

Contrary to the passive, active systems and strategies use contracted energy in order to maintain interior comfort levels. These strategies don't depend on outside conditions and range from HVAC systems; heat pumps; radiant panels or chilled beams; and electric lights; to energy production systems as solar and photovoltaic panels; and wind turbines, among others. Since these energy production systems depend on inconsistent renewable energies, as the sun and the wind, they rely on batteries or the contracted energy from the grid at times of lower production.

In order to enhance and make more efficient the use of renewable ambient sources, there are hybrid systems. They consist on the combination of both passive and active systems, as for example: heat recovery ventilation; solar thermal systems; radiant facades; and geothermal heat pumps, among others.

Even though a small building can easily achieve the desired comfort levels through only passive systems, the combination of both passive and active allow more independence from climate conditions and the grid energy.[80]

[80] According to the literature review: **HEGGER, M.** (2008); **LECHNER, Norbert** (2008); **SCHITTICH, Christian** (2003).

Fig. 6.1 _ C-Mine

Fig. 6.2 _ New Volume

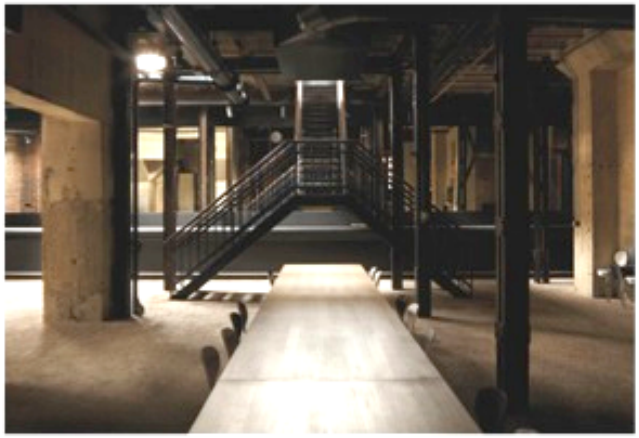


Fig. 6.3 _ Entrance C-Mine
Fig. 6.5 _ Exposition area

Fig. 6.4 _ Circulation/Event's
Fig. 6.6 _ Auditorium

6_ REFERENCE CASES

6.1_ C-MINE _ 51N4E

As an important partner of the Carbon Belt that extends to the Ruhr Area in Germany, the city of Genk has been developing and rehabilitating its derelict large-scale industrial heritage. Thus, as part of this brownfield operation, the city of Genk launched in 2005 a competition to transform the former coalmine industrial building in Winterslag, Belgium, into a cultural centre.

By adding a new theatre hall and a music room to the main machinery hall, the new two structures work perfectly with the old turbine hall T-shaped building. This hall, once the centre of the old coal mine exploration, remained intact as the heart of the cultural centre's circulation. The remaining parts of the building were adapted to house a cultural centre, a design centre, a tourist visitor centre for the coal mine facilities and exploration, a restaurant and, event and exposition spaces.

The old industrial brick building was lightly restored and an extension was made at the ground floor level to support the two new venues volumes. The theatre venues are the only two new volumes that pierce through the base. The white concrete used for the extension as well as the light materials used for the two volumes, reinforce the contrast with the intact old factory, which as the architects say enforces respect.

The project maintains the contrast between the high and low, spacious and covered, dark and light, atmospheres created by the well light high halls in the first floor and the dark covered first floor where the main circulation occurs. The auditorium and music room follow this logic. Steel shutters were used so both venues can either be lit by natural light or darkened.[81]

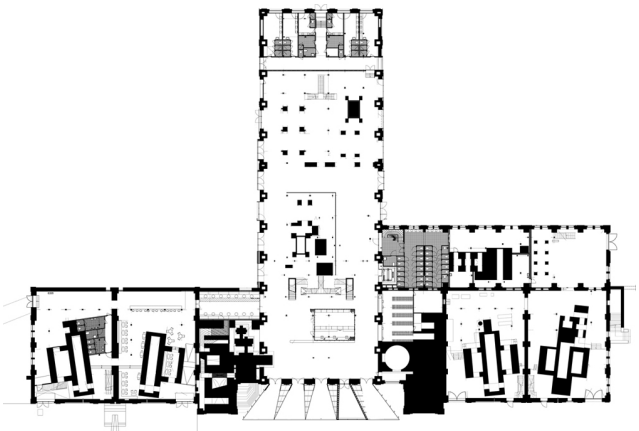


Fig. 6.7 _ Original Factory's Plan

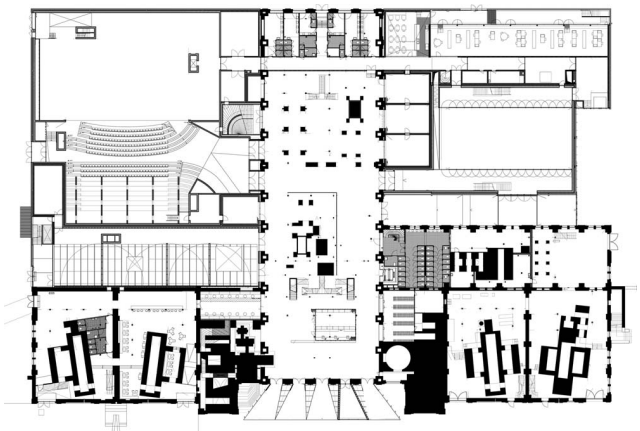


Fig. 6.8 _ C-Mine's Plan

[81] According to guided tour at C-Mine, 2011, Genk; and **51N4E Architects** (2010) C-Mine: cultural infrastructure [online] http://www.51n4e.com/

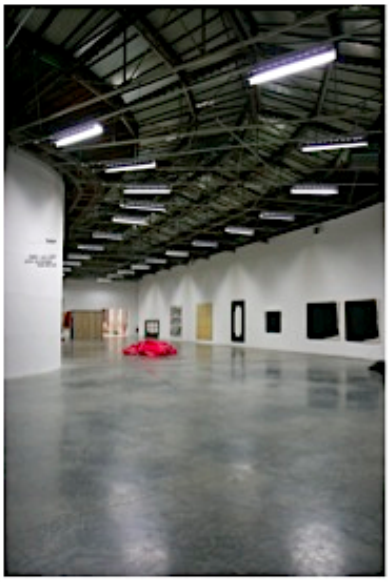


Fig. 6.9 _ Palais Tokyo's site
Fig. 6.10 _ Exposition Space
Fig. 6.11 _ Exposition Space
Fig. 6.12 _ Façades
Fig. 6.13 _ Exposition Space

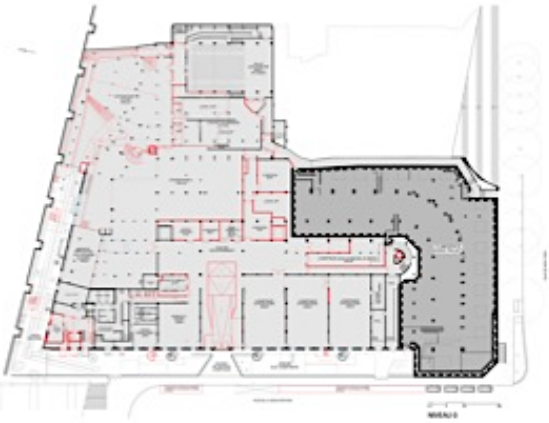


Fig. 6.14 _ Ground floor plan

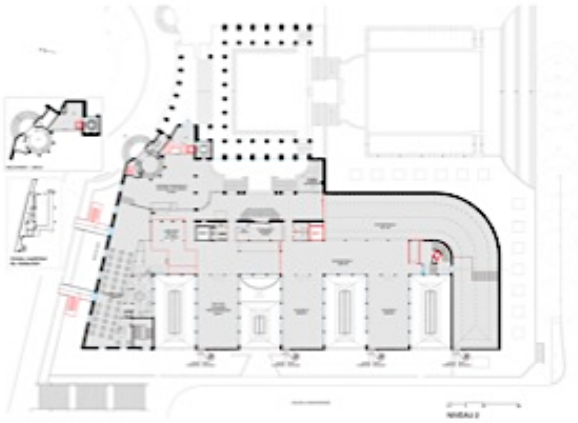


Fig. 6.15 _ Second floor plan

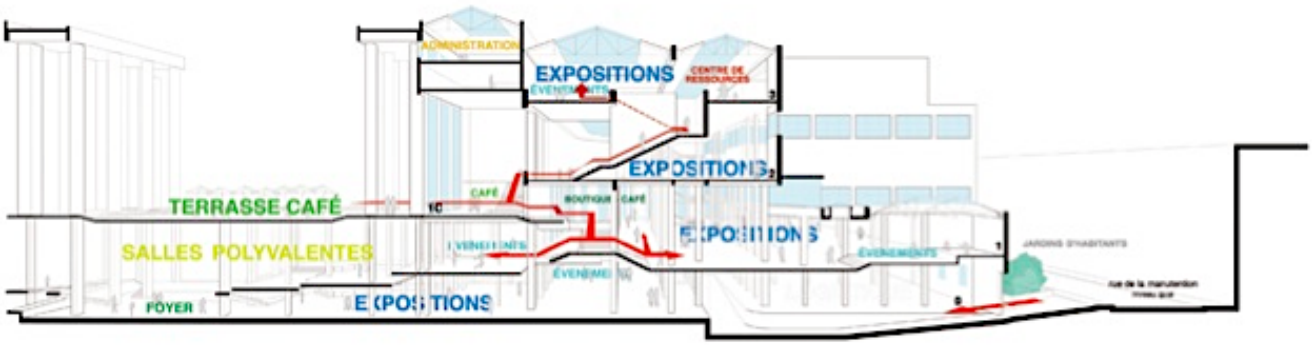


Fig. 6.16 _ Section

6.2_ PALAIS TOKYO _ LACATON & VASSAL

Built originally in 1937 to house the Museum National d'Art Moderne, for the International Exhibition in Paris, the Palais Tokyo closed in 1974 upon the soon to be completed Centre Pompidou. With many years of neglect and subsequent programs, as the "Palais du Cinéma" from 1990 to 1997, the building was left with much of its interior demolished and with fragile and questionable structure. All these transformations left the building, as the architects say, as "a huge black box at odds with the intrinsic qualities of its location."[82]

In 1999 the Ministry of Culture decided to transform the building into a platform for exchanges and direct contact with art, both French and international. This new concept would include the public and give direct access to the process of creation 24 hours a day.

The transformations and demolition processes the building went through, made apparent the 1937 stripped down concrete structure, with the raw materials and the created large volumes now filled with light, once hidden by false ceilings. This industrial, stripped and modern aesthetic contrasted with the monumental façades.

Due to the low budget and the inherited characteristics of the space, the architects went for a small and prioritised intervention, at the scale of an installation. Assuring first the structure stability, accessibilities, comfortable heating and the illumination of the building. Thus, the emphasis would be on the light qualities and the freedom of spaces, the porosity inside as well as with the city. Several openings in the façades and entrances with stairs and footbridges were created in order to create that porosity and at the same time attenuate the monumentality of the façades according to the spirit of the intervention. This relation with the exterior is directly associated with the architects objective of transforming the building in a place of passage and meeting points. Constantly being transformed and evolving according to people's movements. Much like their inspiration, the Djemaa-el-Fraa Square in Marrakesh. This non-partitioning allowed more flexibility and fluidity between the spaces, as well as a complete freedom for users to choose their own way, without a specific dictated route.

By presenting a space that doesn't constrict the art in it, by not fitting in the traditional museological spaces, the building's exposition areas are more relatable conceptually to the contemporary art and more permissive for the public's intervention.

[82] **RUBY, Ilka; RUBY, Andreas** (2010) 2G Book Lacaton & Vassal, Editorial Gustavo Gili SL

Fig. 6.17 _ Aerial view of Fábrica da Pólvora

Fig. 6.18 _ Street View

Fig. 6.19 _ The stream

Fig. 6.20 _ Green Space

Fig. 6.21 _ Outside Spaces

Fig. 6.22 _ Outside Amphitheater

PORTUGUESE CONTEXT

6.3_ FÁBRICA DA PÓLVORA

Located in Barcarena, Oeiras, this factory was founded by the king Manuel I and was known as the smithy of the King (Ferrarias de El-Rei). It worked from 1540 to 1940 as a Gunpowder Factory.

Divided in two buildings by a stream, the factory provided many jobs, which powered the development of the area. Over the years the industrial complex grew and from 1791 to 1869 and from 1895 to 1927, the factory specialised in gunpowder at the service of the army. From 1951 to 1975 it became the Military Factory of Gunpowder and Explosives and finally as simply Gunpowder and Explosives Factory of Barcarena from 1976 to 1988, when it was closed.

The Oeiras City Hall transformed the factory's derelict facilities in a centre for culture in 1994. In order to maintain the memory of the place, a museum of black powder was created to preserve the knowledge, the machinery and the equipment of the trade. The outside spaces, as well as the museum serve as a memorial by integrating in the gardens machinery used and reminiscences of old structures from now non-existent buildings. This is all carefully integrated in the landscape in a way that doesn't feel like an industrial wasteland.

The continuous expansion of the previous factory, created a complex of several buildings with a similar language and different typologies, which now serve the rich variety of services that share the complex. These services include the Museum, exposition and workshop spaces, the Archaeological Studies Centre of Oeiras, the Municipal fish rearing ponds, an Artistic Experimentation Centre and a restaurant/bar. A public park with a sporting circuit, outside spaces like an amphitheatre and some characteristic gardens were created to connect these buildings.

This once derelict industrial complex, by becoming a centre for culture, helped develop and boost that area once again.[83]

[83] According to the literature review: **Oeiras City Hall** [online] http://www.cm-oeiras.pt/; **CORTESÃO, Ana** (2001) A arquitectura da pólvora em Portugal no século XVIII, Lisbon: Faculdade de Arquitectura. Universidade Técnica de Lisboa. Master's Degree in Architecture.

Fig. 6.23 _ Entrance Lx Factory

Fig. 6.24 _ Design Atelier

Fig. 6.25 _ Hole on the wall

Fig. 6.26 _ Outside

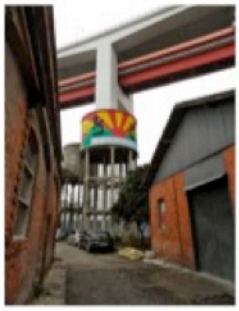


Fig. 6.27 _ Outside

Fig. 6.28 _ “Ler devagar” Bookshop

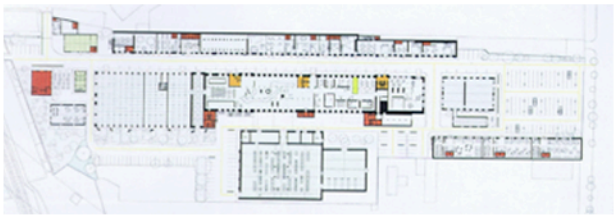


Fig. 6.29 _ Interior Sapces
Fig. 6.30 _ Plan

6.4_ LX-FACTORY

Considered by PARQ Magazine[84] a creative centre with the "highest number of creative people per square meter", this complex was originally a cloth-manufacturing factory from 1846. It was one of the first industries to build worker's houses in the proximities of its installations, and before becoming the Lx Factory the industrial complex went through a series of adaptive uses. First as the industrial company of Portugal and the Colonies and before its closure as a printing industry.

In 2005, the Portuguese property investors MainSide bought the industrial complex and at the time of the Alcântara XXI master plan, the idea of a creative island started to grow. MainSide opened the Lx Factory to public in 2008 and kept the derelict and industrial appearance of the buildings, which were rented for a 5 years period at 6 to 9 euros/ m^2.

In this spirit of the Lx Factory to do only the indispensable of construction works for the correct function of the building, it is possible to see in the second floor of the main building a hole on the wall created by the extraction of a machine. (Fig. 6.25) The hole was kept by putting a window frame behind it, which allowed for the natural illumination of the interior space.

The 23000m^2 complex consists in eleven industrial building blocks with big windowpanes, which offer a wide variety of areas and space typologies. From small offices to 1800m^2 event spaces, there is a diversity that promotes the co-existence of many events and areas of work. Some of the areas that co-exist are architecture, design, contemporary art, advertising, communication, photography, dance, acting, fashion, multimedia and it even incudes a dentist's clinic. The transdisciplinarity associated to the shared services of a cafeteria, restaurants, shops and other facilities; power the creativity as well as the sharing of services by proximity.

Similarly to what happened in abandoned industrial areas in London and New York City, this unoccupied area was boosted through the attraction of creative industries and cultural entities. Even though Alcântara was one of the most degraded areas of Lisbon, with this project it was able to monetize these neglected buildings by keeping its identity and gaining a rich social and cultural life.[85]

[84] Lx Factory: Alegria no Trabalho, PARQ Magazine, November 2009
[85] According to the literature review: PARQ Magazine (2009) November; TimeOUT (2009) 27 May; Arquitectura21 (2009) April; http://www.lxfactory.com/.

Table 6.1. Case references comparison table – synthesis. (Adapted parameters[86])

PARAMETERS		C-MINE	PALAIS TOKYO	FÁBRICA DA PÓLVORA	LX-FACTORY
PROGRAM	Initial	Factory	Museum for the International Exposition (Paris)	Factory	Factory
	Final	Cultural Centre	Contemporary art Museum	Mixed-use Complex	Creative Industries Complex
SITE QUALITY	Qualities	Part of the rehabilitation of Carbon belt extending to the Rhur area; Brownfield operation.	City centre (mixed-uses); Seine riverfront.	Mixed-uses; Part of urban green structure.	Part of the rehabilitation master plan for the area; Proximity to city centre; Mixed-uses.
	Accessibility	Next to interstate road; 2 parking parks; shuttle + bus + bicycle access.	Subway + RER + Bus	Next to highway + main roads; train + bus + bicycle.	Next to main road + train + bus.
PRE-EXISTENCE'S CHARACTERISTICS	In Common	Part of a master plan; derelict void in a city; Solid resistant structure; High open-space typologies.			
	Different	Monumental building; Simple, function-oriented aesthetic; One main volume.	Monumental building; One main volume; Skylights.	Simple, function-oriented aesthetic; heterogeneous complex.	Simple, function-oriented aesthetic; heterogeneous complex.
	Patrimonial Value	Industrial patrimony	Architectonic and historic patrimony	Industrial patrimony	No patrimonial value/ Not Classified
DESIGN TRANSFORMATION	Function	Platform for music and theatre.	Platform to an untraditional interaction with art.	Mixed-use; Local exchange of services; Shared utilities.	Transdisciplinarity; Mixed-use; Local exchange of services; Shared utilities.
	Exterior	Recuperation of the facades; extension contrasts through simple lines and light volumes.	Recuperation of the facades; Small intervention through stairs, footbridges and openings.	Recuperation of the facades; Integration of machines in the gardens.	Minimal intervention; Derelict image.
	Interior	Structure and interior atmospheres are distinct in language and light.	Only structure and accesses kept; Fluid and flexible spaces.	Recuperation of the interiors; Minimal intervention; Original atmospheres.	Minimal intervention; Heterogeneous, function-related interiors.
TECHNOLOGY/ STRATEGIES	Light	Extensions serve as light chimneys.	Demolition: interior partitions, false ceilings (hidden skylights). Larger exterior openings.	N/A	N/A
	Heating/Cooling	N/A	N/A	N/A	N/A
	Energy Production	N/A	N/A	N/A	N/A
	Water	N/A	N/A	N/A	N/A

[86] **Adapted from:** (2010) Reconversão de espaços industriais: Três projectos de intervenção em Portugal; (2008) Energy Manual – "SIA 112/1, sustainable construction"; (2006) Ambiente e Constução Sustentável.

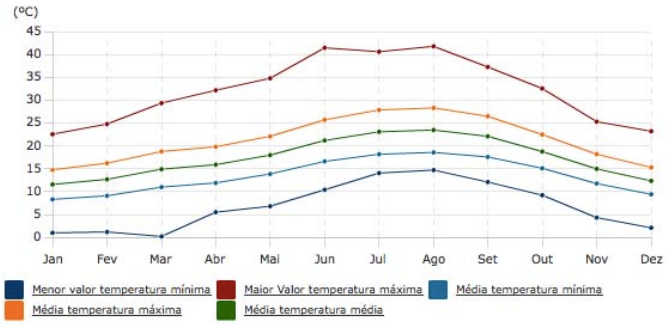
6.5_ MAIN LESSONS

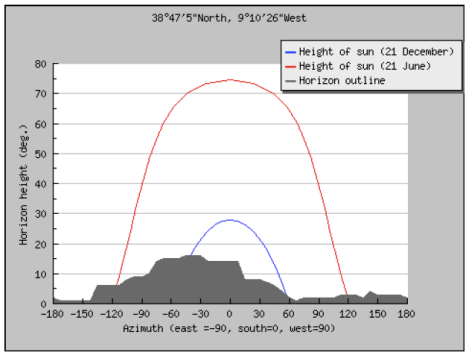
The four cases chosen come from a master plan, or powered one due to their intrinsic association with the community, and the dynamic effect of a previously derelict area. In addition, in every case most of the buildings structure and atmosphere was kept. In some cases this choice was made for economic reasons and in others by the designer's choice.

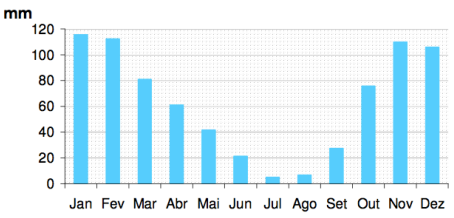
The C-Mine is incorporated in the carbon belt rehabilitation as part of a green network of rehabilitated infrastructures. Its rehabilitation combines the restoration of the old factory as the core of the building with two volumes as an extension. It is this extension that will provide the necessary infrastructures, contrasting with the original building both in exterior language as in interior atmospheres. Therefore the new addition respects the pre-existence without either overpowering or blending in with it. This project also offers an example of the extension used as a way to correct the pre-existence's deficiencies, as the use of the new volumes as light chimneys.

The Palais Tokyo is an important example for both program and design. For it provides a platform where the public is able to interact with art and the building beyond the traditional contact. The small and prioritized intervention assures the stability, comfort and services, emphasizing on the light, flexibility and fluidity between spaces. The intervention also contrasts with the existing building by the use of stairs and footbridges, which provide a closer relation with the exterior and soften the facades' monumentality.

The Portuguese case references contextualize similar premises. Both cases consist in industrial complexes, which provide a wide range of services that coexist and create interesting interactions, while being unified by the public space and similar exterior image. The Fábrica da Pólvora's rehabilitation concept comprises diverse programs, which can work independently. The Lx-Factory's organizational scheme and diversity in program generated transdisciplinarity and exchange of services. This proved to be successful in providing an innovative and creative atmosphere, as well as the connections to allow the growth of projects. This diversity associated with sharing the same utilities enables the local exchange of services and boosts the local economy.







	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez
Precipitação (mm)	115,4	112,2	80,9	60,9	41,4	21,2	4,9	6,7	27,4	75,7	109,7	105,7

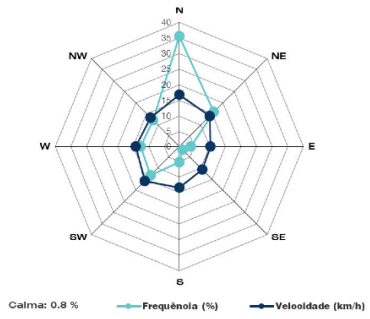


Fig. 7.1 – Air temperature, Lisbon 1981-2010

Fig. 7.2 – Monthly average precipitation, Lisbon

Fig. 7.3 – Outline of horizon with sun path for winter and summer solstice

Fig. 7.4 – Wind average annual velocity

7_ INNOVATION CENTRE BY DESIGN WITH CREATIVE COLLABORATIONS

7.1_ PROJECT FRAMEWORK

LOCATION

Odivelas, Portugal
Lisbon District (approx. 10Km distance)
38º 47' 06'' N, -9º 10' 25'' E

CLIMATE

With approximately 26 km² and an average elevation of 49m above sea level, Odivelas has a Mediterranean climate (climatic classification of Köppen-Geiger: Csa), which means an average temperature above 10ºC in the warmest months and between -3ºC and 18ºC in the coldest ("C"). It has dry summers ("s") and an average temperature above 22ºC in the warmest of at least four warm months ("a").

December and January have the highest precipitation and humidity levels and the lowest temperatures. July and August, on the other hand have the highest temperatures and the highest wind velocity and frequency, as well as the lowest precipitation and humidity levels.

Temperature

Low thermal range (average between 11,4ºC and 22,8ºC)
Low average temperature of the coldest month – January
8,2ºC
High average temperature of the warmest month – August
27,9ºC
(41,5ºC Absolute maximum)

Precipitation

Average annual precipitation – 74 mm
Low average precipitation – July – 4,9 mm
High average precipitation – January – 115,4 mm

Insolation

(of the exact building location)
Average annual insolation accumulated – 4,99 kWh/m²
Low average insolation accumulated – January – 3,16 kWh/m²
(5 hours of sunshine)
High average insolation accumulated – July – 6,76 kWh/m²
(11 hours of sunshine)

Humidity

Average annual humidity – 73%
Low average humidity – July/August (3pm) – 63%
High average humidity – January (9am) – 82%

Wind

Average annual velocity – 14 km/h - (10>17 km/h)
Low wind velocity and frequency (<14km/h) – October
High wind velocity and frequency (>14km/h)– February, May, July and August

7.1.1_ URBAN CONTEXT

Historic, Social and Economic Context

Part of the metropolitan Lisbon area, Odivelas is first mentioned in 1147. It was the king Dinis who promoted the small village's growth by constructing a monastery of cult nuns, which attracted artists and the nobility.

The existing city was previously a small urban development focused on agriculture. Its growth was caused by the construction of residential housing to support Lisbon workers, which happened in different time spans with distinctive characteristics and resulted in a fragmented city. Both in the field of accessibilities and urban infrastructures, as in typologies and city image: The historic centre surrounding the monastery; the illegal neighbourhoods created in the twentieth century, which due to its proximity and the creation of a road to Lisbon, allowed for it to become in the sixties and seventies one of the most populated urban areas; the west area of Odivelas, the Cruzeiro Hill that owing the new access with main regional roads allowed an expansive growth of housing in the nineties.

Contrary to the other areas the historic centre is rich in public facilities and commerce, even though the commerce is not diversified. The services and facilities are concentrated in strategic cores surrounded by housing. This housing focus characteristic of Odivelas doesn't offer enough job and investment opportunities for the local economy. Thus relying on the city of Lisbon and functioning as a dormitory.

Territorial Planning and Management Instruments

Part of Lisbon's metropolitan area, Odivelas is characterised for a high density of residential infrastructures associated with a necessity of public facilities, as well as poles of local employment and investment. The planning and management regional instruments for Odivelas (PROT) present four priorities. To achieve:

1. Environmental Sustainability through the preservation and valorisation of the riverfronts and the green structure of parks and urban gardens. This should be attained by the implementation of a green network connected by ecological corridors and connections;
2. The qualification as part of the metropolitan area as a means of creating a new centrality with good accessibilities and ability for expansion and

development. The new centres should be autonomous and independent, though connected to the city of Lisbon.

3. Social and Territorial Cohesion through the regeneration of the illegal neighbourhoods, integrating them in the urban facilities network. At the same time it should create equal opportunities for employability and promote public-private partnerships.
4. The improvement of the accessibilities and public transportation network in order to reduce the use of individual transportation and the necessity for parking installations.

According to the Municipal master plan of Odivelas (PDM) the area where the project is located is an uncharacterised area of environmental valorisation, due to the urban gardens for agriculture (North) and the hill with natural vegetation (South). These areas serve beside their ecological function as a limit for the urban growth.

The plan addresses the importance of converting urban derelict areas as well as urban voids. This regeneration of the urban fabric should be associated with the valorisation of green areas and with the implementation of renewable energies. Therefore developing a new qualified urban front to provide a new and unified city image.

Accessibility and Transports

Odivelas presents three types of accesses (Fig.X): The subway stations, two main regional roads (IC17 and IC22), and the urban internal network. The distribution concept of this internal network consists in the use of main distribution streets and roundabouts. It lacks in internal relations between all the areas, directing the traffic to three main streets.

Along with the energy use of the building, the means of transportation of the users is important in the emissions produced. Located next to one of the two subway stations from the Lisbon metropolitan area in Odivelas, the building creates a front to one of the main entrance roads for the city. These conditions associated with the urban master plan proposed, make the building accessible on foot and by bicycle, in addition to the local transit. Electric cars would be proposed for the everyday users of the centre as an output for the peaks of unused electricity produced, and as a means of reducing emissions caused by the centre's activity.

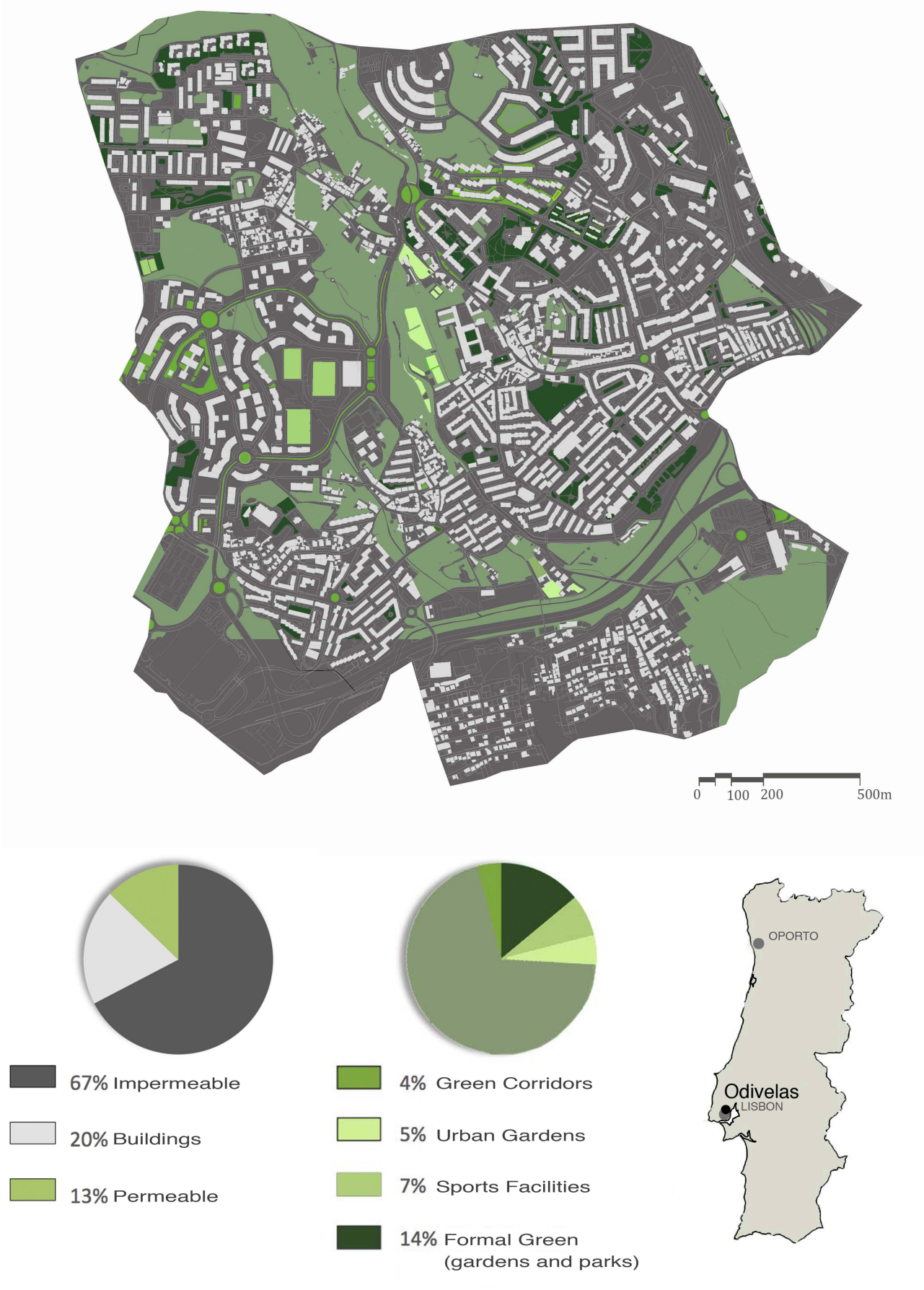


Fig. 7.5 – Green Structure

Public and green structure

The historical centre has a big offer of public and green spaces, however the Cruzeiro hill and the illegal urban area (AUGI) have an almost total absence, due to their dubious semi-public characteristics, which doesn't promote the common use by the community.

The Cruzeiro hill was created with new construction. It is dense and urbanized. It's public and green spaces seem to be constricted to the residual spaces left by the built buildings in the lots.

The urban illegal areas on the other hand, by being built with illegal housing, doesn't follow an urban plan, occupying the space without the creation of sidewalks and public shared spaces.

These three zones are connected physically, though separated accesses wise by the abandoned riverfront. Which presents optimal conditions to create a relation between these three characteristic parts of the city, through the public space of an urban park.

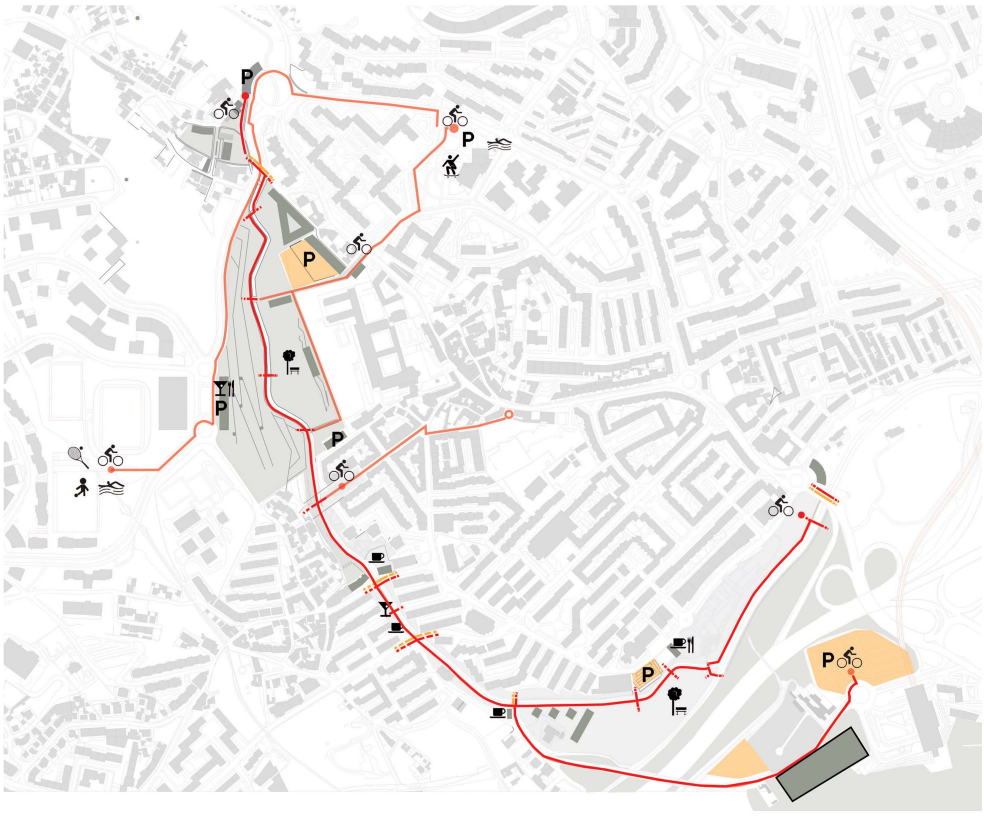


Fig. 7.6 – Urban Park path

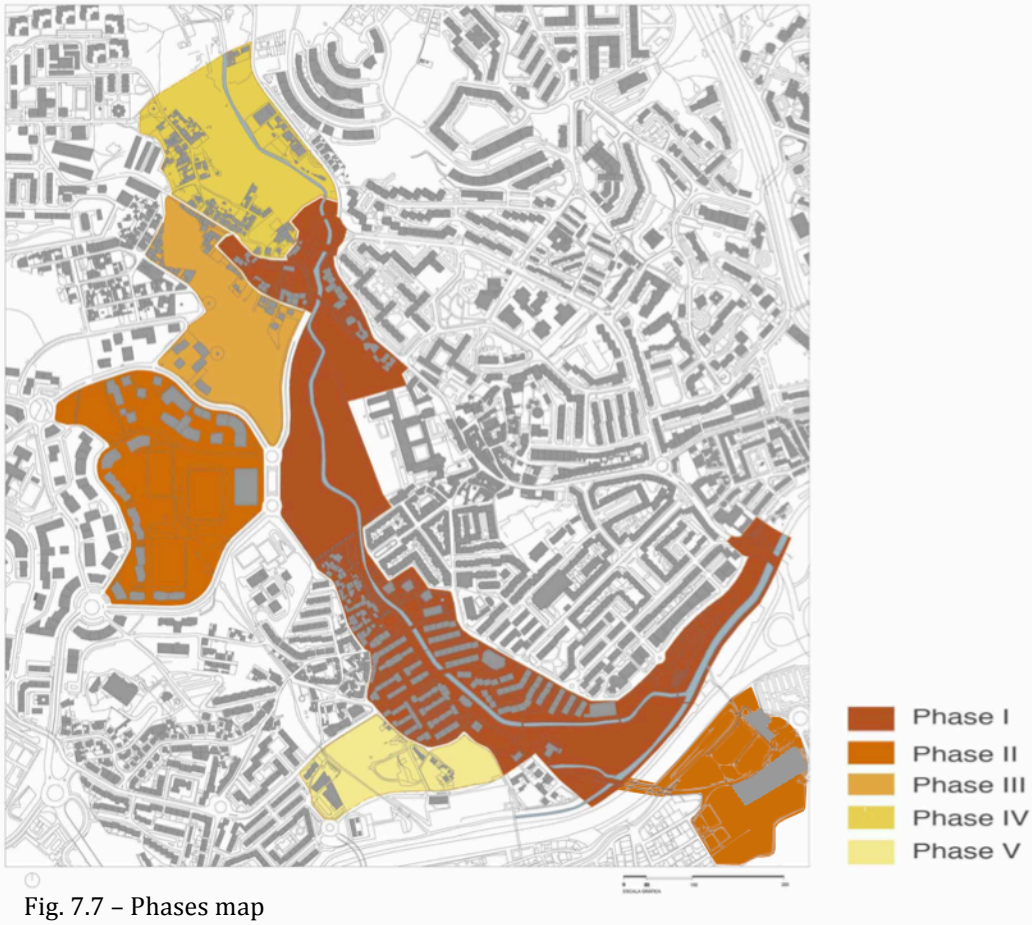


Fig. 7.7 – Phases map

Urban Project

The project consists in an urban park, which by following the waterline connects Odivelas, promoting the pedestrian circulation and the use of the bicycle. At the same time, it rehabilitates an apparently forgotten area of the city, the riverfront.

The park design is based on a space/time relation. Since every 10 minutes on foot (approximately), are marked by a bridge and an important public building at the beginning of a new zone (North Business area; Community; Cultural; Commercial; and South business areas).

Urban Park as urban catalyst

The urban park serves as a promoter of the urban development. By extending throughout the riverfront the park creates value and rehabilitates the river transforming this current obstacle into a connection.

Taking advantage of the existent park in the south of the city, the linear urban park will have its two extremes at the north and south main roundabouts. The north one connects the three areas of the city, and south roundabout is the entrance to the city near the subway station. This way, the park creates cycling and pedestrian circuits from north to south, connects the whole city and stimulates new economical and technological growth through the incorporation of new markets.

With this key in mind it is essential a fazed execution plan. The five stages of the urban project are:

Phase I _ A main structural intervention to connect all the areas of the city by regenerating the riverfront. This intervention will provide the necessary infrastructures for the master plan.

Phase II _ The development of two centres: The existent sports area into a sports core by the addition of a velodrome. This will attract a new economy to the area and promote the use of bicycles as proposed in the first phase. In addition to an Innovation by Design centre based on renewable energies with working and investigation areas (the case study). These two developments will provide the economic boost to create viability and affordability for the remaining phases.

Phase III _ The construction of a "Living Science Centre" (Centro de Ciência Viva) integrated in the urban park. The building will continue as an exterior science experiences museum.

Phase IV _ The regeneration of the urban identity. This will comprise the rehabilitation of abandoned houses and the windmills, integrating these last ones in the urban park (some as part of the exterior science museum).

Phase V _ The creation of an eco-quarter for housing and working based on sustainable economic, social and ecologic strategies.

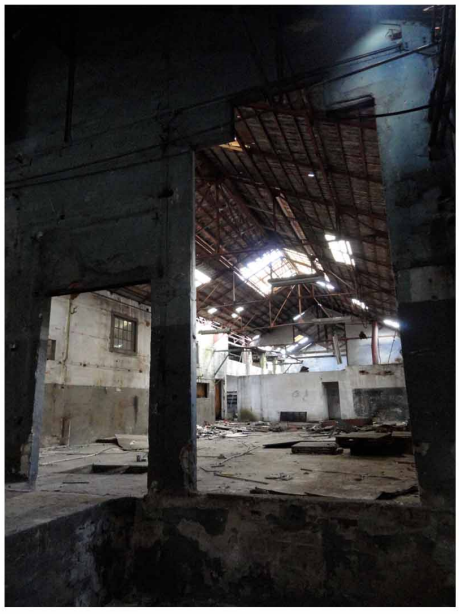


Fig. 7.8 – Warehouses' Exterior

Fig. 7.9 – Car pathway

Fig. 7.10 – Warehouse's Interior

Case Study

Connected to the south of the urban park and at less than hundred meters from the subway station, the buildings chosen for refurbishment are derelict industrial buildings. Even though a part of the complex appears in maps from the beginning of the twentieth century, the first and only information and drawings found are from the extension constructed for the Thermo-Electric Constructions Company, CONTEL. From the existing buildings it is possible to assume that at least three other companies occupied the space: A kitchen furniture company – TMA; Montoya & Amorim, Lda; and PONT-A-MOUSSON.

The complex stands out in the landscape for its architecture and volume that contrasts with the subway station. With only one street front, the northwest facade faces a main entry road to Odivelas and is framed by the green hill (south). Thus working as a front city image.

Description of the existing state

The 7500 m^2 industrial complex comprises fifteen buildings, eight of which connected internally. These buildings present different construction time-spans, associated with the use of wood, metal or concrete pillar structures. In addition, it is possible to detect from their formal language different programs, as administrative and services buildings for workers, large open machinery spaces and storage facilities. Each building adopted its own structure and dimensions according to their needs, though keeping as common elements: the pitched roof, a long and narrow volume of masonry walls and concrete floors construction. Therefore the complex is heterogeneous, connected only by a partly similar formal and architectural exterior language.

Concentrated, given the buildings' wall-to-wall construction, the complex provides two main entrances. One in the northwest facade, direct to the main road, and another for trucks and cargo in the northeast. The 1500 m^2 of external accesses and yard are covered in old uneven cement over untreated land.

Due to the abandonment and illegal use of the buildings, three of the volumes fell from natural causes and another was burned down. Given the unknown conditions of the buildings and that a part of the complex already collapsed, it is important to study in detail the structure during the predesign phase. In addition the slabs and soil should be tested for the accumulation of oils and heavy metals, due to the anterior presence of machinery. In order to adjust the strategies of the refurbishment it is important to

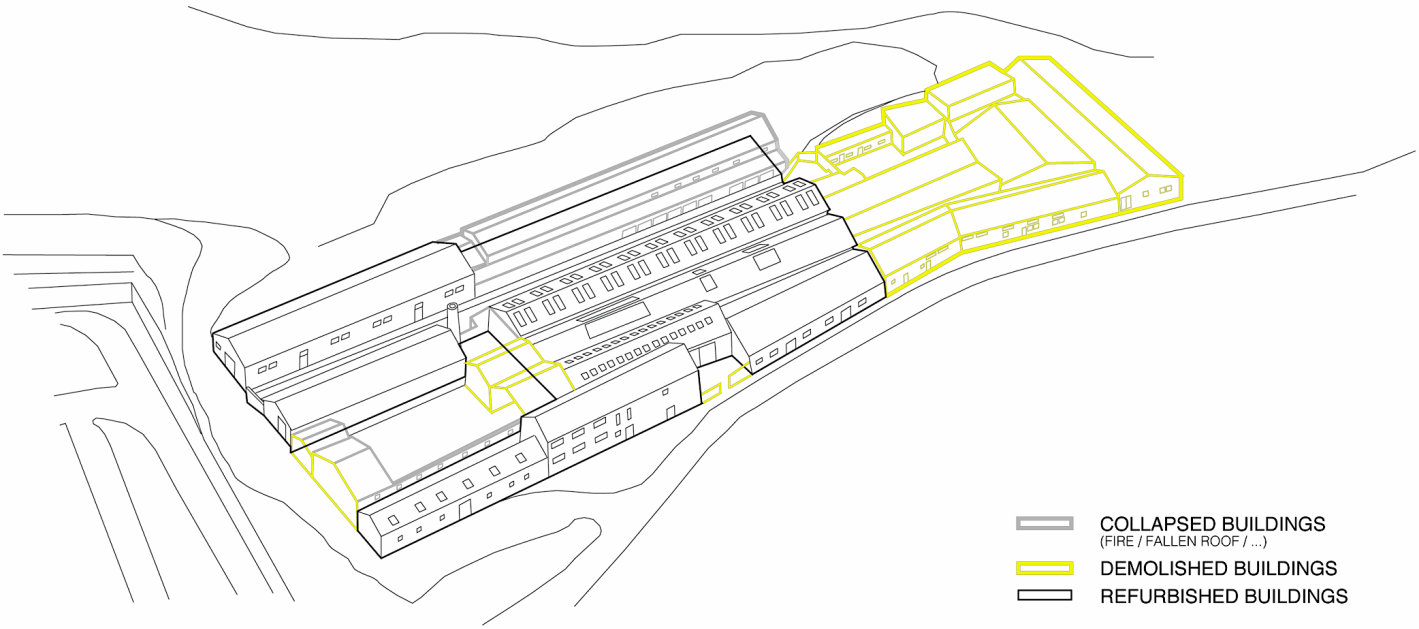


Fig. 7.11 – Demolition scheme

analyse these components and the inherent thermal and lighting performance of the buildings.

Use, recycle and disposal proposal

Part of the most recent construction, the sheds in the south-west side were demolished due to their construction characteristics, as well as for their different language, orientation and organizational system. The demolition of these buildings and the removal of the already naturally demolished ones will be selective and careful. This way it is possible to separate the building materials depending on their destiny:

Re-use (for the refurbishment or other buildings):

- Roof metal sheets
- Roof ceramic tiles
- Metal structure

Recycle:

- Roof metal sheets (that can not be reused)
- Roof ceramic tiles (that can not be reused)
- Metal structure (that can't be reused in the refurbishment)
- Wood structure and elements (i.e. doors)

Transform:

- Masonry and concrete walls into light non-structural filling concrete or greed, for exterior pavement and levelling.

Dispose:

- Dangerous materials as the asbestos cement according to the environmental regulations.

The existing buildings conditions allow the maintenance of most of the existing infrastructure. Though due to the degradation state of some elements it must be subjected to some alterations and recuperations in order to assure the current norms for health, fire and safety.

Once completed the operations of removing the redundant materials, it is possible to start the insertion of the new organizational system (to accommodate the program) and the creation of a new efficient skin.

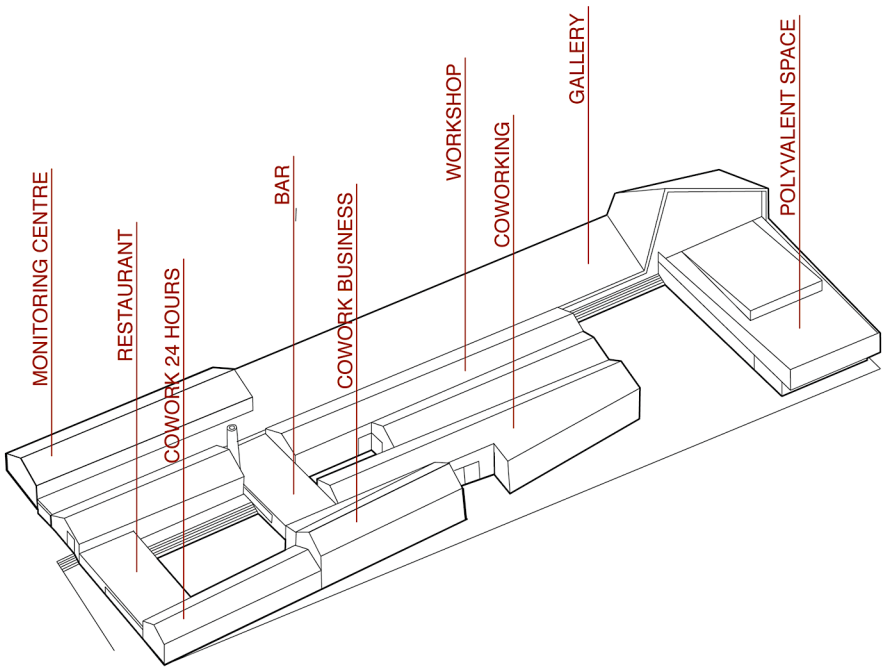


Table 7.1. Program with basic features and loads (Adapted and compiled[87])

PROGRAM	ZONE 1			ZONE 2		ZONE 3	ZONE 4	ZONE 5
	Exposition	Library	Bar	Coworking + Fab Lab	Workshop	Polyvalent Space	Restaurant	Parking
AREA (m^2)	2 188	540	250	1 873	315	2 616	257	8 400
People/100 m^2	33.5	10	35	3.5	5	75	35	2.5
People Sensible Heat Gain (W/person)	73	73	81	73	81	73	81	73
People Latent Heat Gain (W/person)	59	59	81	59	139	59	81	59
Lighting Load Density (W/ m^2)	11.8	14	14	10.9	15.1	17.2	14	3.2
Equipment Load Density (W/ m^2)	10.8	10.8	8.5	14.4	10.8	5.8	8.5	3.2
Outside Air (ventilation) Flow Per Area (m^3/h/ m^2)	3.7	3.7	3.7	3.7	1.1	3.7	3.7	27.4

[87] **Adapted and compiled from:** http://buildingsdatabook.eren.doe.gov/; http://sustainabilityworkshop.autodesk.com/; http://wikihelp.autodesk.com/.

7.2_ PROGRAM

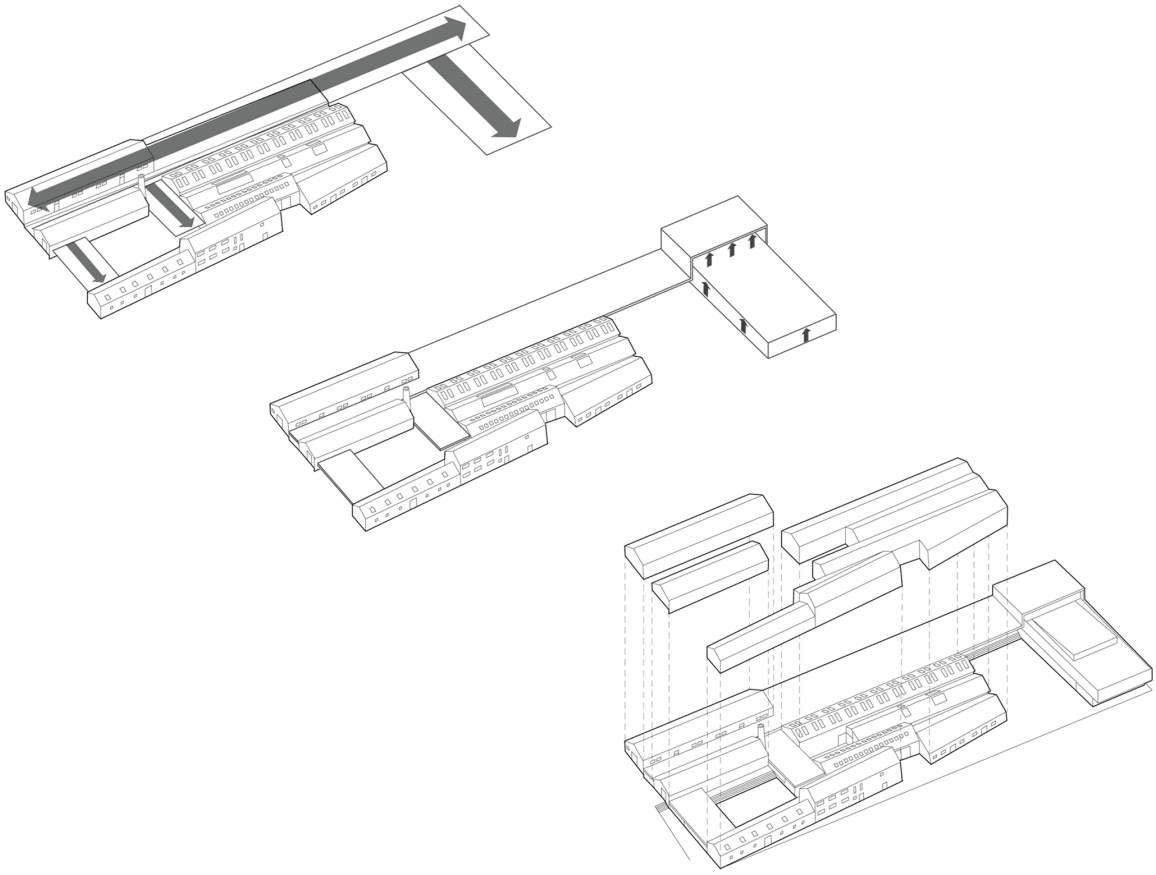
The Centre for Innovation and Design (CID) aims to create diversity in uses in the neighbourhood as well as a new centrality associated with the urban master plan. In a smaller scale the CID aims to foster innovation by informing and promoting the integration of diverse groups of people from a wide range of areas, through the transdisciplinarity allowed by design. By connecting itself to the MIT Fab Lab group, to the European Creative Institutions, and in future to other national cities, the access and exchange of knowledge could create a dynamic platform. Thus fostering new design solutions for the current challenges in the environmental, social and economic fields.

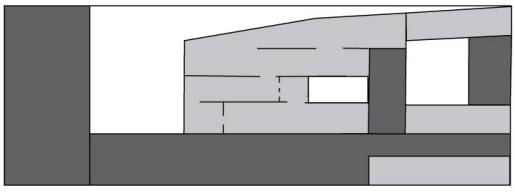
The CID complex comprises an exposition area of the building's sustainable strategies and created projects, a public small library focussed on sustainability and design, a restaurant and a bar, a polyvalent space, a Fab Lab with a workshop space open to the public, and a Cowork facility.

In order to promote a more efficient performance, the CID's services are organized in zones. Each zone can work independently, which reduces the loads of the building, according to each zone's program schedule.

The building's energy loads consists in the amount of energy needed for an interior comfort level[88]. It can be for thermal or lighting comfort and it is electricity, fuels or passive systems that provide it. These loads can be external, or internal. The external are created by the sun, wind and climate through the building's envelope (outer skin and windows). The heat generated from people, equipment and artificial lighting creates the internal loads. The determination of these loads depends on the site and the program (Table 7.1).

[88] Sustainability Workshop: Building Design concepts: Site planning and energy loads [online] http://sustainabilityworkshop.autodesk.com



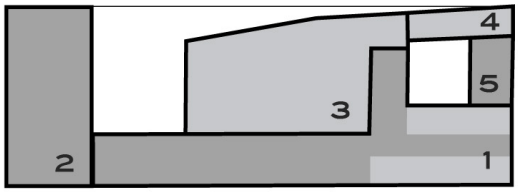


INTERVENTION SCHEME

CAPTION

REFURBISHED BUILDINGS

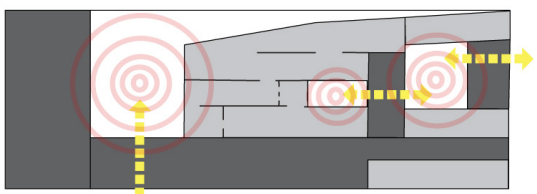
NEW INTERVENTION



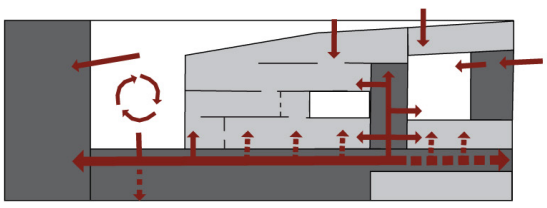
ZONES SCHEME

CAPTION

GALLERY _ ZONE 1
POLYVALENT SPACE _ ZONE 2
COWORK _ ZONE 3
24H SPACE _ ZONE 4
RESTAURANT _ ZONE 5



EXTERIOR GARDEN/SQUARES
AND VISUAL LINKS



MAIN DISTRIBUTION CONCEPT

Fig. 7.12 – Design schemes

7.3_ DESIGN CONCEPT

Providing a front to one of the most important entrance roads to Odivelas, the building's main facade is characterized by the relation between two distinct bodies, the pre-existence and the new intervention. The main entrance is created by a small square, which establishes a visual connection with the green constructed wetland on the south side of the building. A second entrance for the cowork space was created in a pre-existent cut out in the facade, which ruptures the unified surface and creates a smaller, more restricted access.

Characterized by the glare pitched roofs and two story long volumes, the refurbished existing buildings, accommodate the Coworking, the Fab Lab spaces and the small library. The extension will provide the working facilities (innovation machines) with the support infrastructure and services, as a restaurant, a bar, an exposition / monitoring area and a polyvalent space.

Existing Buildings

In the existing buildings the original structure based in space-saving metal trusses should be treated and restored in order to support new light insulated roofing panels. The fitting-outs and interior walls were removed, with the exception of the shower's area, which was adapted to a new shower area for the workshop and cowork spaces. This action of removing superfluous elements allows a flexible use of the internal space. The services, the new second floor structures and the accesses are the only fixed elements. They support the open-spaces and allow for a possible future different program.

Taking advantage of the exterior walls of the buildings, more exposed to the northwest side, a new insulation skin was added with modules of sandwich panels in a prefabricated dry form of construction. An air chamber created behind the new optimized surface area accommodates the drainage, electrical and vent ducts. At the same time it creates an air barrier that creates an efficient thermal barrier and complements the insolation. This allows an easy maintenance and shows the building as a unified element. The modern envelope thus translates a new identity and the aims of the building of creating a new front for the city

New Intervention

The intervention was created in a way to connect and support the working facilities located in the refurbished buildings. Thus creating and promoting new internal relations through new entrances and accesses. The former access path for loading trucks that crossed the complex – a negative volume - was transformed into a gallery: A linear long volume in the south side, which connects through an exposition space the working facilities with the library, the bar and the polyvalent area.

The new volumes shape and their transformation from simple angular volumes resulted from the integration of passive and active strategies. This way the systems would not be treated as a posterior addition but as part of the design process. They are present in the experience the users have of the building.

With simple and clean lines, these dark volumes contrast with the rich pattern and forms of the existing buildings. On the interior the structure is hidden and the spaces are kept clean and open to provide a flexible internal layout.

7.4_ TECHNOLOGY AND STRATEGIES

The existing buildings were built to face the local climate without technical installations. Therefore the interior space is sectioned in zones and the orientation is primarily towards the north. This allowed natural ventilation, natural diffuse day lighting and a minimization in heat gains (since there were high internal loads from the machines).

Even if the building's volume and orientation in the existing buildings cannot be easily changed, energy optimization is achieved through the envelope, which provides illumination through double glazed solar protection glass, sun shade and solar radiation in critical places. The intervention on the envelope, on both new and existent buildings, consists in the creation of an optimized surface area with high thermal insulation quality. Though, it still allows the wind to help with the natural ventilation in warmer months through controlled air inlets. Reducing this way the heating and cooling loads.

Due to the removal of the redundant materials and parts of the buildings, new open semi-public spaces were created. These wind-protected areas improve the quality of the building's interior through natural lighting and ventilation. The landscape project of these new semi-public open areas and the surrounding of the building involve native species with low maintenance and low water consumption.

The maintenance and improvement of the green structure, the sun shading, the wind-protected areas, the rainwater collection and the permeable ground, as well as the creation of natural habitats through a constructed wetland or grey water treatment garden, generate an improvement in the microclimate.

7.4.1_ PASSIVE AND ACTIVE SYSTEMS

LIGHT

In conventional office buildings the energy used for artificial lighting approaches 40%[89]. Therefore, in order to have optimized lighting conditions, the intervention seized the cleared spaces of demolished buildings to create open exterior areas. These gardens provide as much natural light as possible at the heart of the existing buildings complex. Due to the concentration of buildings in a wall-to-wall construction, skylights and the

[89] **SCHITTICH, Christian** (2003) In Detail: Solar architecture, Birkhäuser Architecture.

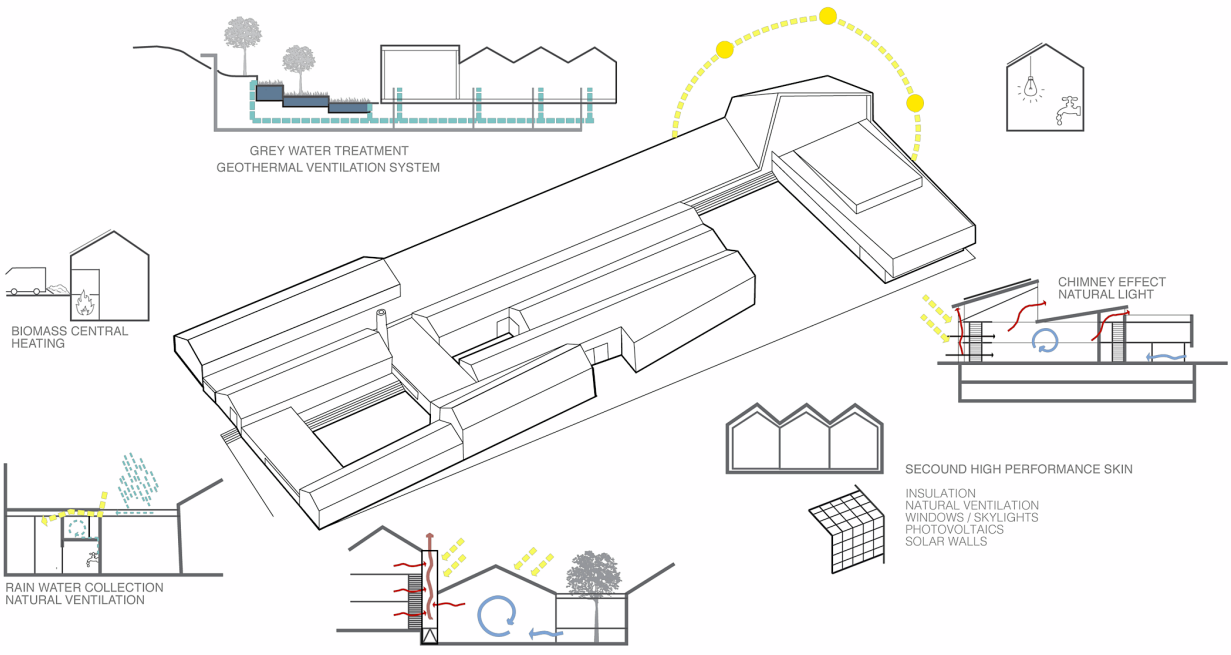


Fig. 7.13 – Technologies and strategies scheme

interior garden will provide most of the natural daylight. This eliminates the need for artificial illumination during the day. In some spaces, reflective surfaces and efficient task lights will be provided to reduce the use of artificial room lighting and heating gains.

HEATING / COOLING

Since it is necessary three times the amount of energy to cool a space 1ºC than to heat it[90], and due to the average higher temperatures during most of the year, the building's envelope took advantage of the surface area/volume ratio. The concentrated volumes decrease the exposed areas for heat transfer. The strategy focussed on avoiding heat loads by use of natural ventilation with air inlets and air recovery, sun shading and a night cooling system in warmer months. The use of the building's thermal mass, solar and trombe walls as well as a sun house will avoid higher heating needs in the colder months.

The heating and cooling strategy in the polyvalent space will comprise passive systems as the chimney effect in the two staircases, which provides natural ventilation and helps to cool the space. The southeast staircase will be integrated in a glazed double facade with air inlets on top in order to prevent overheating. Due to its characteristic air renewal demands and others present in the legislation, when needed, the building will use an efficient HVAC system (Heating, Ventilation and Air conditioning) with heat recovery. The natural ventilation provided by the two chimney systems in the access stairs will assist the HVAC system. When the needs are not high, the natural ventilation can be used alone.

The remaining spaces will use the following active strategies:

In the Cowork area, the Fab Lab and the Library a radiant hydraulic under-floor heating will be implemented. Three solutions were considered:

- Solar panels as suppliers for the floor heating were discarded due to the inexistence of an outlet for the produced hot water in the summer months. The panels would have to be covered and inactive during half the year, which would not be efficient and would increase the payback time.
- A geothermal system associated with the floor heating was considered. Though according to *Geotermia Portugal* in the Lisbon area the amplitude of

[90] **LECHNER, Norbert** (2008) Heating, Cooling, Lighting: Sustainable Design Methods for Architects, Wiley.

ENERGY SOURCES	Current Price	Heat Power	Conversion Efficiency	Energy Price (cent/kWh)
Natural Gas	0.090 €/kWh	10.53 kWh/m³	90%	10.00 cent/kWh
Heating Diesel	1.35 €/L	10.15 kWh/L	90%	14.78 cent/kWh
Propane Gas (LPG)	2.16 €/kg	12.87 kWh/kg	90%	18.65 cent/kWh
Electricity (100% / full hour)	0.178 €/kWh	-	100%	17.80 cent/kWh
Electricity (100% / empty hour)	0.096 €/kWh	-	100%	9.57 cent/kWh
Solar Energy	0	-	100%	0
Pellets (Max. 10% humidity)	0.25 €/kg	4.90 kWh/kg	90%	5.67 cent/kWh
Firewood (Max. 20% humidity)	0.15 €/kg	4.00 kWh/kg	90%	4.17 cent/kWh
Heat Pump (100% / full hour)	0.178 €/kWh	-	(3.5 C.O.P. of annual average efficiency)	5.09 cent/kWh
Heat Pump (50% full/ 50% empty)	0.137 €/kWh	-	(3.5 C.O.P. of annual average efficiency)	3.91 cent/kWh

Table 7.2. Heating energy costs (Adapted[91])

[91] **Adapted:** www.solius.pt/calculadora/.

temperatures is low and the lowest temperatures are close to the underground ones. Therefore, the system would not be efficient.

- The most efficient and clean solution for the building's dimension and location is the Biomass energy. (table 7.2)

Biomass Central Heating

A single biomass boiler connected to the radiant hydraulic floor heating provides the central heating and supports the sanitary water heating when there is a peak of loads. The technical area for the boiler, the buffer tank and the measuring and control systems are in the exposition space along with the controls and monitoring of all existing active systems to allow visits.

The characteristics of the system for this case study are: A buffer tank with a capacity of 25 tons and a volume of 45m^3. The unloading is direct through gravity; A Biomass boiler with a capacity of 450kw; The boiler is fuelled by any biomass with less than 25mm as wood pellets, almond bark, olive pits, among others.

This system is 100% CO^2 free because the CO^2 released in the combustions is the one imprisoned by the plants. It also represents a cradle-to-cradle system, for its raw material is the organic debris considered a source of pollution and fire hazard. Its ashes (the remains) are used for composting.

Solar panels for sanitary water heating

Two systems of solar panels will be used: One array of three panels with a 400 l deposit for the restaurant; One array of five panels with a 500 l deposit for the bar and the showers. (These values were based on the estimation for the restaurant (15l/meal) and for the showers (50l/shower))

The support will be given by the thermal central through a second serpentine in each deposit. In addition the electric resistance present in each deposit can be used punctually.

ENERGY PRODUCTION

Sun

The photovoltaic modules implemented both on the refurbished buildings as in the new intervention does not function only as a power-generating system. Due to their density and opacity level, they also regulate the shading and indoor climate, protecting it from overheating with the direct sunlight.

In the polyvalent space, these modules also help the efficiency of the natural ventilation chimneys through natural convection. This system also helps cooling the photovoltaic panels, increasing their efficiency.

The photovoltaic modules cover Xm^2 and have an energy supply of approximately X kWh/a.

Wind

The wind-based systems in this area do not work to their full potential due to the average of 4m/s of wind velocity (6m/s is the minimum velocity for a good performance). Since this building's exposition area serves as a centre for monitoring the behaviour of the active and passive systems of the building, it would be interesting to integrate them. We propose three small wind turbines with a vertical axe and a production capacity of 2kW each (with an estimation of 16 kWh/day for each turbine). These wind turbines are urban and silent. They would be integrated in the garden with the grey water treatment wetland and serve as a visual mark.

Control and Monitoring

The control and monitoring of the energy production and performance criteria of the building's strategies will be presented in the exposition area through an interactive board, as well as in the building's web page. The information would include the climate data; the building's conditions (as indoor air-quality and thermal comfort); the percentage of energy produced and used comparing to the percentage of energy needed from the grid (Smart Grid Concept); and the building's green strategies, their features and live performance data.

WATER

The maintenance of the existent green structure in association with a constructed wetland for grey water treatment serves as a limit for urban development. The constructed wetland specifically, besides its function of recreating the cycle of water through the recycling of a resource and cooling the south facade in hot months, serves as a limit for the south facade of the building. It creates a path, framed in parts by the exposition area, which bounds people to see the building from a determined distance, as a whole.

With rainwater collection, grey water recycling, and water saving fittings, appliances and irrigation, the building does not require reductions in water use by the occupants. For it still manages to reduce the consumption of municipal potable water through a good water system design. (In some cases these measures can reduce up to 50% of water consumption.)

Table 7.3. Case study's synthesis table. (Adapted parameters[92])

PARAMETERS		Criteria / Indicators	Description	
			Refurbishment	Extension
PROGRAM	Initial	Industrial Complex	CONTEL - Thermo-electric constr.; TMA; PONT-A-MOUSSON	
	Final	Innovation Centre by Design with creative collaborations	Fab Lab and workshop space; Cowork; specialized library; restaurant; bar; polyvalent space; exposition area with building's showcase of its technologies and strategies.	
SITE QUALITY	Qualities	Rehabilitation of derelict industrial complex; Inserted in a master plan; Mixed-uses.	Part of the rehabilitation master plan of the riverfront; multifunctional building; serves as a limit of urban growth for the south green area; Use of area already developed.	
	Accessibility	Next to interstate road; 2 parking parks; subway + bus + bicycle access.	Central position; subway (100m) and Bus (in front); The use of private transports are minimized due to excellent location and transport's accessibility; Creation of Bicycle park and underground parking.	
PRE-EXISTENCES CHARACTERISTICS	Image	Simple, function-oriented aesthetic and structure; Heterogeneous complex.	7 500 m^2; 15 concentrated volumes, 8 of which connected internally; Derelict complex; Strong and resistant structure due to previous function; High open-space typology with skylights;	
	Patrimonial Value	No patrimonial Value/ Not Classified		
	Waste Management	Re-use, Recycling, Transformation and Disposal plan.	Demolition of uncharacterised and naturally partially demolished volumes; The industrials machines were already not present; Dry construction; Use, recycle and disposal proposal.	
DESIGN TRANSFORMATION	Function	Platform for Innovation	Transdisciplinarity; Mixed-use; Local exchange of services; Shared utilities; Alternative concepts of use for the spaces.	
	Exterior	Maintenance of pre-existences' volume language; Extension contrasts through simple lines and materials.	New skin, which integrates technical elements; Easy maintenance dry construction with national materials – Life Cycle oriented.	Dark and simple angular volumes resulted from the integration of passive and active systems; Semi public square (Social contact)
	Interior	Structure and interior atmospheres are distinct in language and light;	Reinforcement of the apparent structure; Small intervention through redefinition of accesses, services and illumination openings; Open plan quality is kept - Fluid and flexible open spaces.	Structural elements are concealed; Internal layout is flexible and adaptable through an open design – Life cycle oriented; Efficient concentration of services in strategic locations.
TECHNOLOGY/ STRATEGIES	Light	Maximization of natural light associated with task efficient energy saving bulbs.	Demolition of interior partitions; Bright interior surfaces; skylights and facade openings; interior gardens.	In the polyvalent space the stairs serve as light chimneys;
	Heating/Cooling	Zoning; Efficient envelope; Maximization passive strategies associated with heat recovery natural ventilation; Active systems from renewable sources.	Compact buildings; Good insulation; Passive systems as sun shading and night cooling; Heating through carbon neutral (biomass system) and renewable sources (solar, wind).	
			Thermal mass of existing building as climate buffer; Solar wall; radiant hydraulic floor heating; interior gardens.	Polyvalent space: Chimney effect (stair elements); double façade; efficient HVAC system. Exposition area: Trombe wall.
	Energy Production	Use of renewable energy sources.	Local production of energy; efficient production through optimization of energy use systems and monitoring;	
	Water	Efficient water system.	Caption of rainwater; Treatment of grey water.	

[92] **Adapted from:** (2010) Reconversão de espaços industriais: Três projectos de intervenção em Portugal; (2008) Energy Manual – "SIA 112/1, sustainable construction"; (2006) Ambiente e Constução Sustentável.

8_ RESULT DISCUSSION AND CONCLUSIONS

This dissertation studied the three components of sustainability, with the intention of understanding their ramifications, for a more complete project. It was important to understand how every action interferes or restricts other component's options, focussing mainly on the social component. Based on these principles, the answer to fulfil all needed criteria should be integrated through the architecture (program and building design). Consequently, both the international and national reference cases were important as a successful answer to this refurbishment/program/design problematic.

The chosen buildings have present in their specificity, characteristics that inspired the case study, as they highlight the reference cases as urban regenerators, and at the same time, serve as a bridge in the growth and evolution of the city. For example in the C-Mine case the new intervention does not overpower or blend in with the rehabilitated building. On the contrary, it contrasts both in exterior language and interior atmospheres, while proportionating a unified building and conferring the present day standards of comfort and technology. Given the focus on the social component and the inherent characteristics of the case study, the project followed the circulation approach from Palais Tokyo. The circulation is fluid and becomes a scenic, barrier-free path that connects the different programmatic spaces and emphasizes their flexibility and unity. Even though the case study's original building has in common with the Lx Factory its non-patrimonial value, the refurbishment concept followed a different approach. Focussing instead on the reference case's organizational scheme and diversity of program, which proved to be successful in proportionating an innovative and creative atmosphere, as well as the connections to allow the growth of projects.

Through the Portuguese reference cases, it is possible to prove that the industrial buildings from the twentieth century are not limited to their most common program national wise: cultural or museum. In fact, these now commonly obsolete buildings present architectonic characteristics that allow a simple reconversion to programs from office buildings to some types of schools, or housing. This is due to their structure (thought for heavy loads and big dimensions), which is the most valued element and in less need of transformation.

With the purpose of creating sustainable value, the unqualified obsolete industrial buildings should more often be considered in studies of sustainable rehabilitation. The integration of these structures in the urban fabric, not only translates as a reduced

footprint, but also brings benefits for the urban environment and the local community. Urban regeneration reuses an existing structure with economy on materials, energy, means and capital; creates value from derelict structures, part of the local identity and diversity; and promotes a continuity of the local urban image and social memory.

The rehabilitation or refurbishment works are therefore an opportunity to improve and qualify the existent built environment. In the case study's example, the intervention provides a way to qualify the public space of an illegal urban area (AUGI). These areas are subject to bad quality or inexistent public space due to their illegal construction.

The urban project implements cycling and pedestrian paths through an urban park, which connects to a subway station from Lisbon's metropolitan area. This promotes a reduction in the use of cars and consequently the noise, traffic congestion, parking overloads, air pollution, as well as a reduction in the social costs associated with these problems. Therefore, the location and the urban design instigate the use of public transportation and raise the attractiveness of local residential, shopping, cultural and touristic areas. By providing accessibility, availability and affordability, the centralization of the city is reduced and the social equity promoted.

Both the urban project with its phased process and the case study with its different zones allow a phased construction process, which promotes a more efficient and economically viable construction. In both scales, each phase makes the next one more viable and, in some cases it can help pay for the next phases' cost. i.e. the cowork facilities can work individually and support part of the investment costs for the gallery and the polyvalent space.

The case study consists in the conjugation of a refurbishment of non-qualified industrial buildings with a new intervention. Therefore, the concerns on the case study and the conclusions are different from what a rehabilitation of a qualified building would need or present. The main limitations found are due not only to this conjugation of different architectural interventions, but also to the high level of criteria that constraint the comfort and the energy needs of the building. The balance of all these criteria demands a mastery of a vast general knowledge from all areas, which complement and interfere with each other. For instance, when one solution for a component of sustainability compromises another, or the language and image of the project, it is important to have a hierarchy and reach a consensus or equilibrium. Otherwise, the project could lose itself to a random non-relatable group of solutions that compromise each other's functionality and the building's image as a whole.

The limitation of the technology still does not allow for a high efficiency from the systems, regardless of the position or application mode. With the future legislation and the increase in demand for these systems, architects will be obligated to stop ignoring or hiding these elements. They will increasingly be integrated in the design of the building itself, which will condition and transform the formal language of the architecture.

Simultaneously, the increased demand for flexible and interdisciplinary work places, brought by globalization, technology and new forms of work, as freelancing, foster the creation of such centres. These new economies boost the others and create diversity and growth through an innovative urban centre, with synergizing technology and an improved quality of life. A new dynamic and specialised community is created with a high potential capital. The investment is justified, both socially and economically. In addition, the use of environmental friendly materials, the design of waste disposal and recycling strategies as well as energy efficiency, among other strategies, don't affect only the environment and comfort. They allow for an increase of revenues as well as a long-term viability of use.

8.1_ FURTHER DEVELOPMENTS

Within the framework of this study some key points arose that would complement the dissertation or promote future investigations.

a. A study on how to evaluate and calculate the social component and the passive systems would promote a better understanding and integration of these systems in the building's design. Diminishing at the same time the discrepancy of comparative value in the certifications criteria.

b. The marketing and growing demand for green certifications by the clients, has turned them into guidelines for green building. It would be interesting to understand how this project would qualify in an international and national system: for example LEED (which offers more importance to the systems and technologies implemented); and LiderA (whose criteria is based on the three components adapted to Portugal). As a parallel study, it would be interesting to see which direction the project would follow with each certification in mind.

c. The quantification of the impact of adopted materials, solutions and systems through the Life Cycle Assessment would allow the creation of a comparison table of the possible options and their performance over time. Since each material's Life Cycle Assessment involves many factors, it is a long process to take for each project. This table would be an interesting and important support for future projects, and maybe the origin of a database for professional use.

d. In order to better assess the building's Life Cycle, it is important to carry an exhaustive study of the materials produced in the proximity, their extraction, characteristics and behaviour. For future projects the national database being created by LiderA (www.4rs.eu.pt) and the Eco platform, by Construção Sustentável, can be used for that information. This database not only makes available all necessary information, as it makes the ecological products more competitive. It can work similarly to an ecotax by making the knowledge of the long-term savings public. The rise of the competitive level and increase in demand will also increase production and consequently allow a lower price.

e. On a following phase, a detailed study of every zone could be conducted in energy calculation programs. Which would lead to a more accurate choice, dimension and application of the systems, since they were chosen based on, or

adapted from built examples with similar characteristics of climate, use and/or comfort needs.

f. The implementation of a similar project would be interesting, to study if it is possible to fulfil the premises of local development, economic and cultural growth, as well as the more active part the city would play in an innovation platform.

(19 451 words)

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